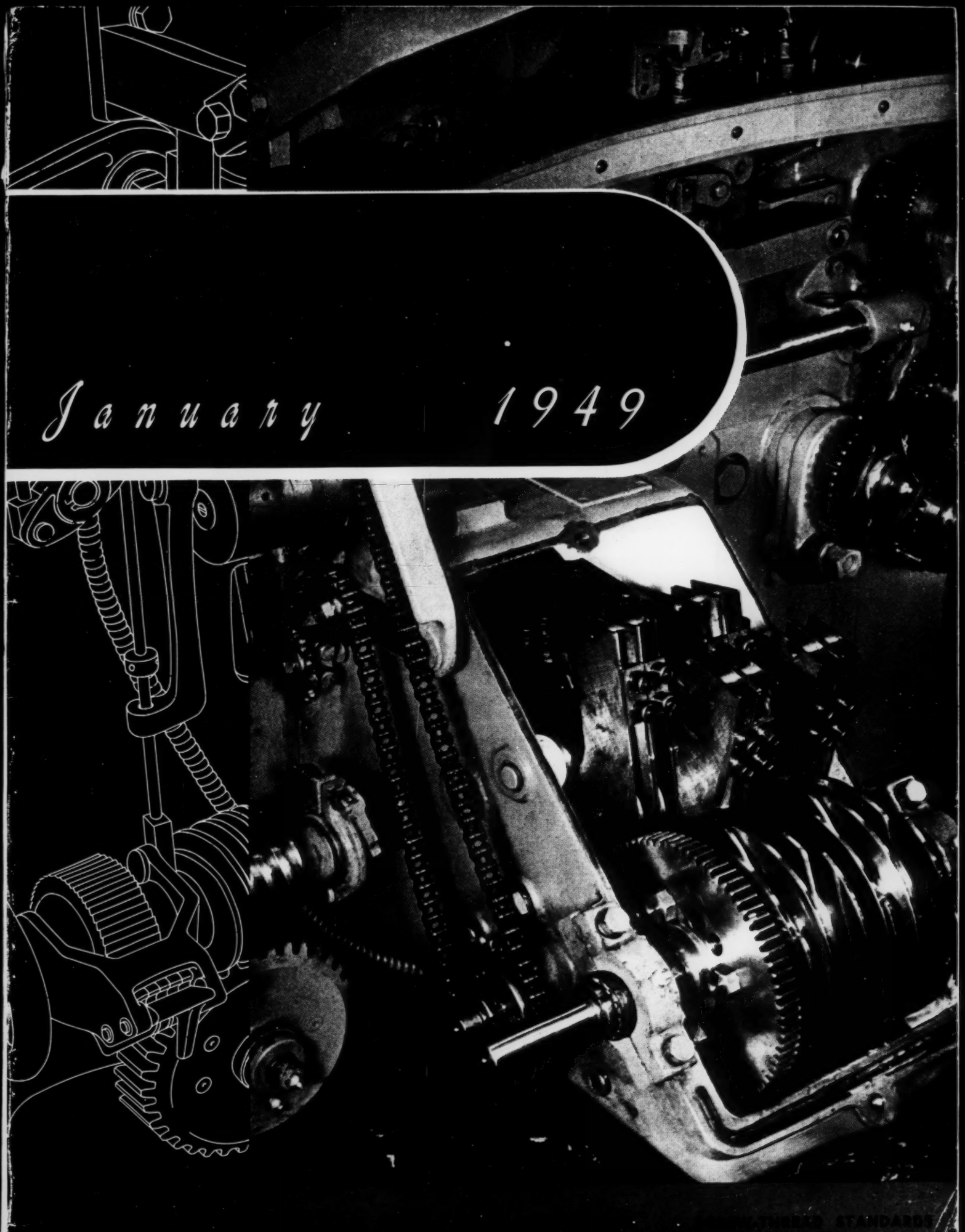
January 1949

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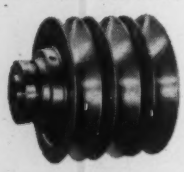

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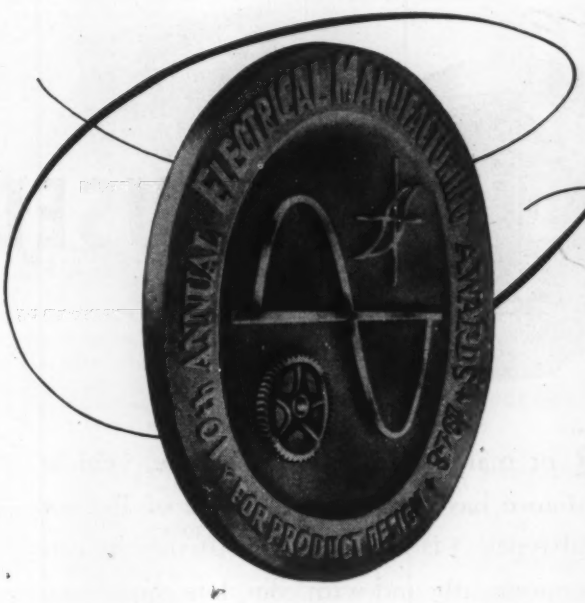

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USES A

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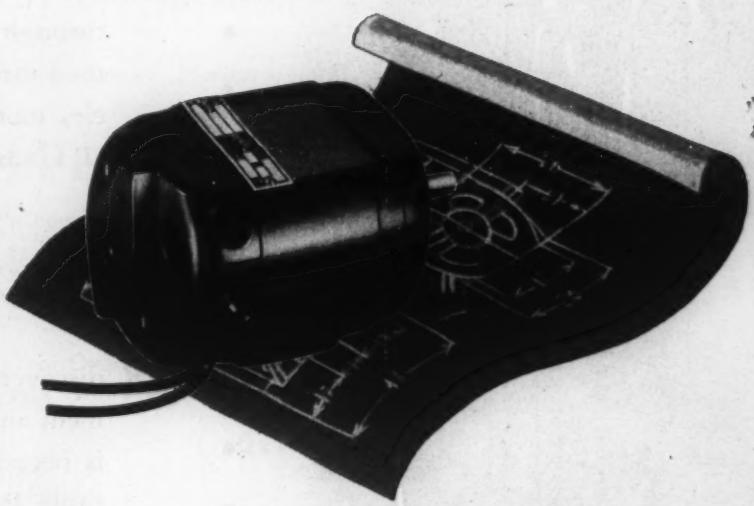

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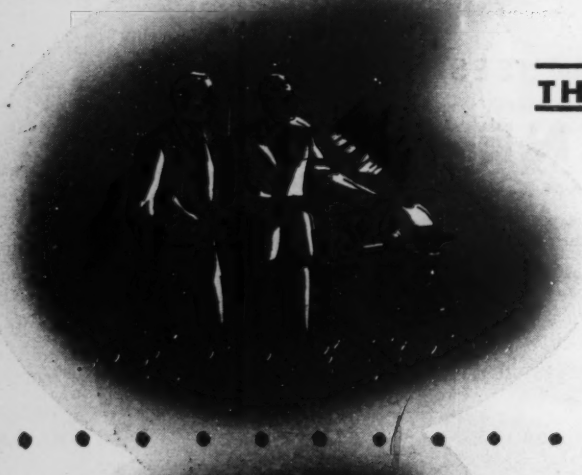

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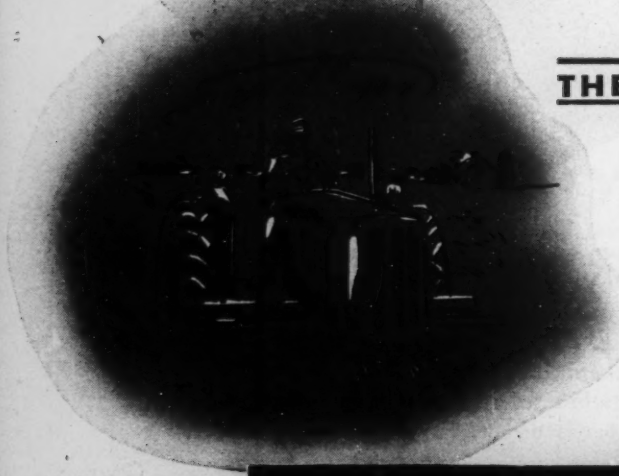

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This Month's Cover: Box for operating harness drive on Warner & Swasey textile machine. Design features and revolutionary weaving principle of the machine are discussed in the article beginning on Page 79.

MACHINE DESIGN

Vol. 21—No. 1 January, 1949

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

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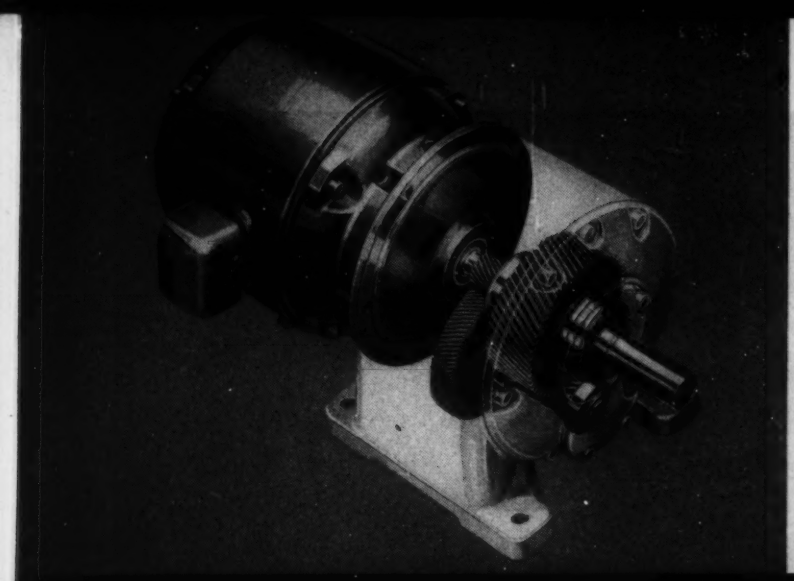

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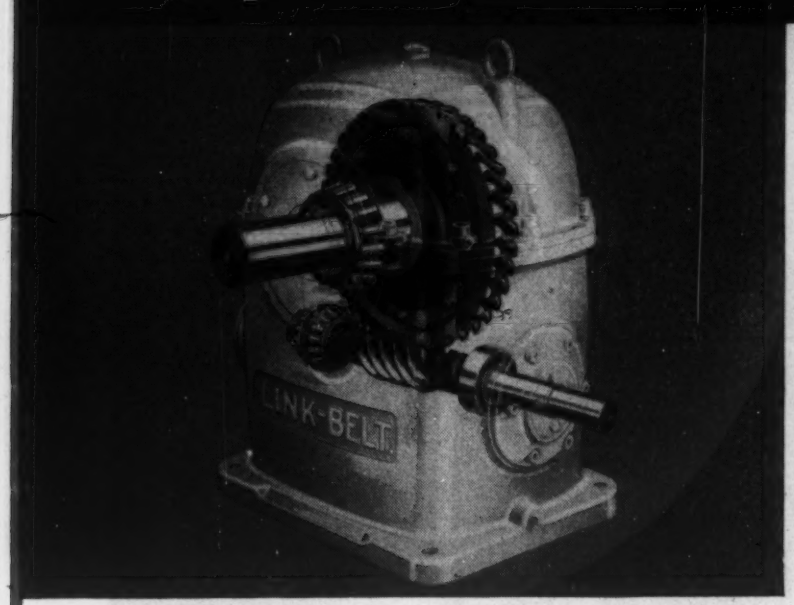

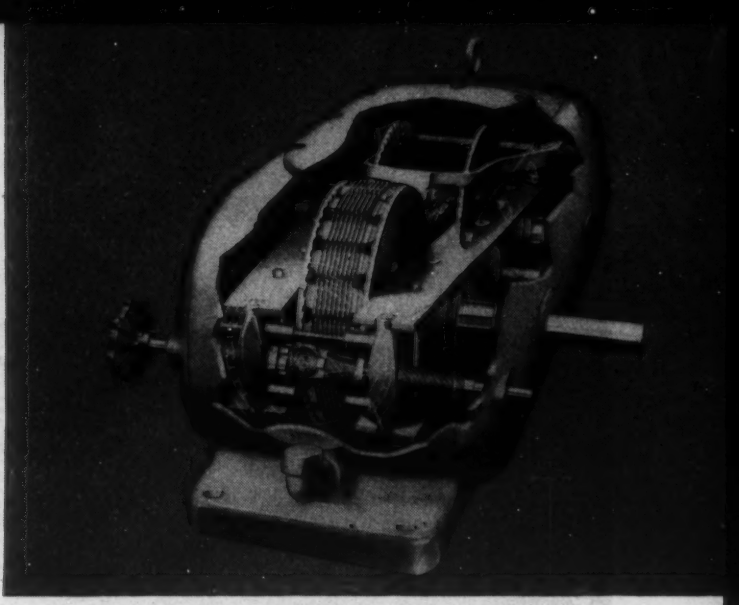

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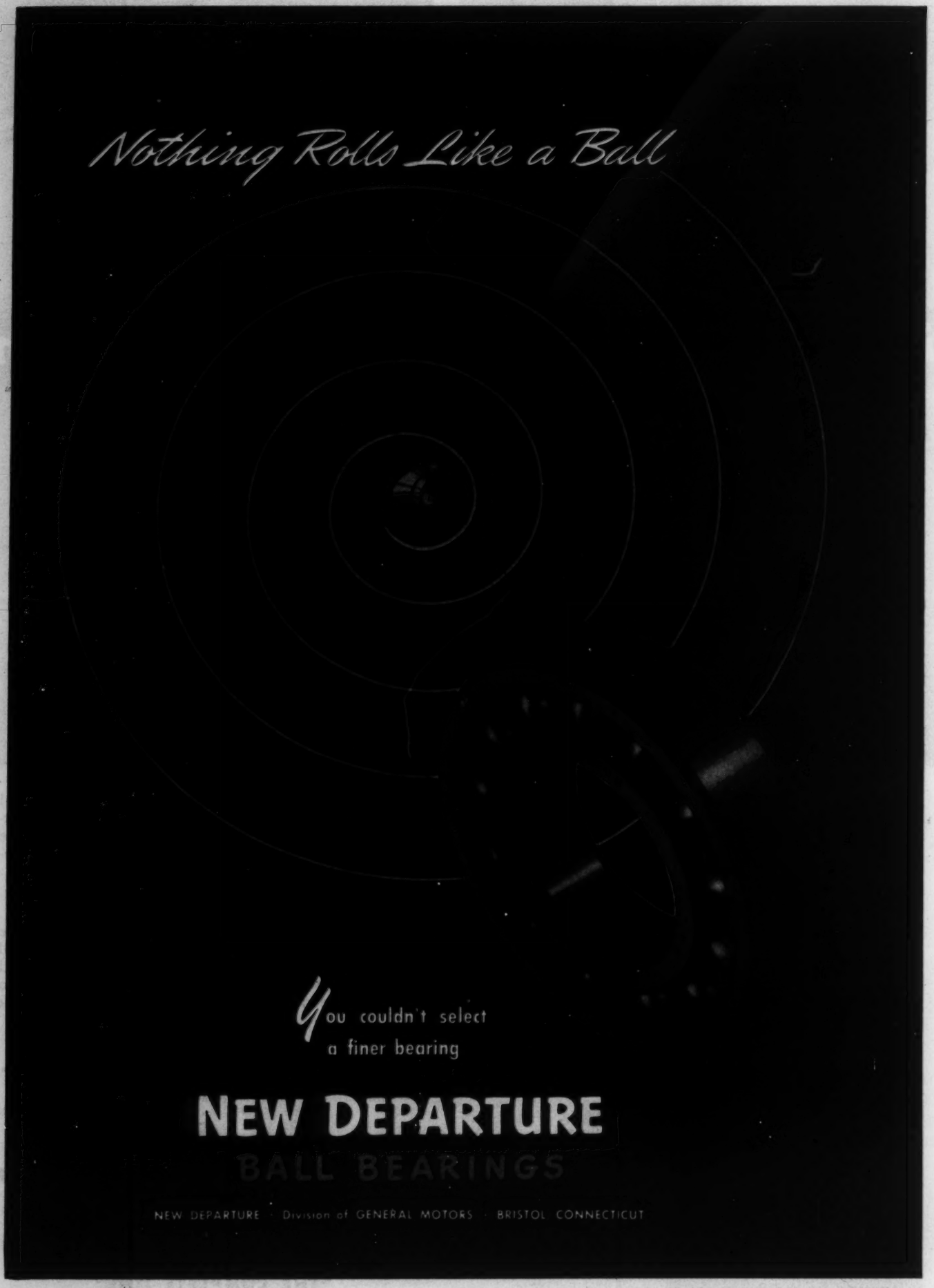

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NEW DEPARTURE

BALL BEARINGS

NEW DEPARTURE · Division of GENERAL MOTORS · BRISTOL CONNECTICUT

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Rivnuts solve tough problem in NEW BUILDING DESIGN

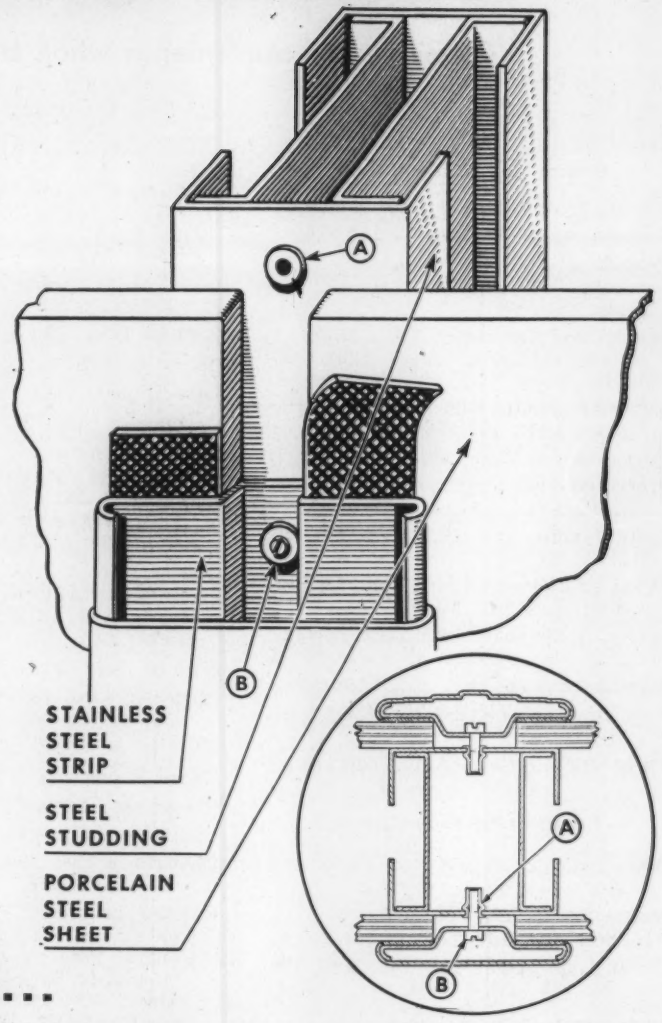
Architects for a "quick-lunch" restaurant chain had an exceptionally tough problem in designing their new pre-fabricated building. Walls of porcelain steel had to be attached to the steel upright studding in such a way that they could be easily torn down and moved. Good sealing was a must. Because B. F. Goodrich Rivnuts serve as both blind rivets and nut plates, they provided the ideal solution.

FLAT HEAD RIVNUT

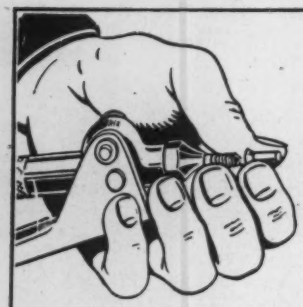
Rivnut "A" is inserted in the studding and upset. Its flat head and the firm bulge formed in its shank grip the studding tightly. The still-intact Rivnut threads furnish a deep nut plate for attaching the walls.

When threaded into the Rivnut, cap screw "B" securely fastens the steel strip (which holds the porcelain sheets and asphalt sealing) to the studding. A trim strip is snapped into place to complete the outside assembly. Interior panels are similarly attached.

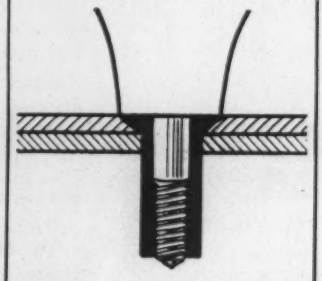
Because these walls can be removed quickly and easily for either moving or repair, Rivnuts mean big dividends in time and money saved. If *you* have a fastening problem, why not consult a Rivnut engineer? Write to The B. F. Goodrich Company, Dept. MD-19, Akron, Ohio.



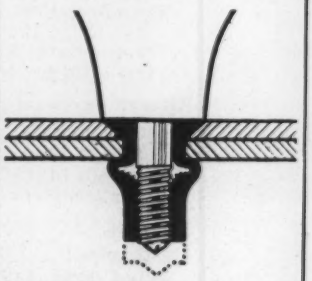
. . . installation is simple and quick . . .



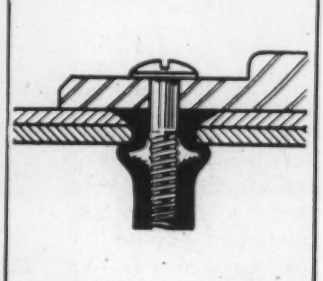
1. Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



2. Rivnut is inserted —with head firmly against, and at right angles to, work.



3. Tool lever operates to retract pull-up stud, forming a bulge in the Rivnut shank.



4. After upset, Rivnut threads are still clean and intact, ready for screw attachment.

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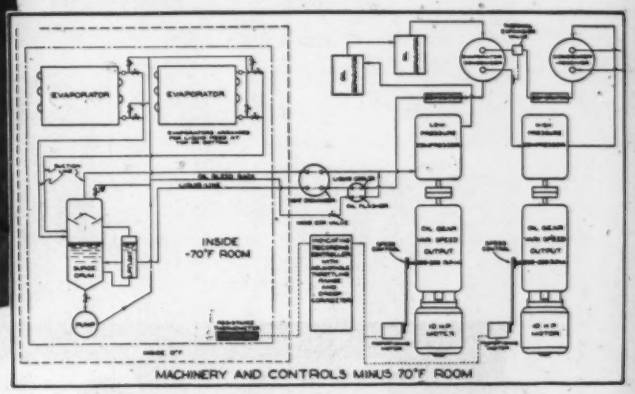
(Photo and Schematic from Refrigerating Engineering)

Two Oilgear Fluid Power Transmissions driving compressors for research laboratory's —70 degree testing room. (Other Oilgear Transmission drives compressor for 0 degree room.) Output speed of transmissions varies according to temperature differential upon resistance thermometers. Control of speed is entirely automatic. Manual control for starting is optional. Oilgear Fluid Power Drives and compressors operate continuously. (See schematic below).



MACHINERY AND CONTROLS MINUS 70°F ROOM

OILGEAR *Fluid Power* SOLVED THIS PROBLEM

The wide range of installations that demonstrate the reliability, scope and ease of control of Oilgear Fluid Power Drives and Transmissions grows daily. A case history from REFRIGERATING ENGINEERING, official journal of the American Society of Refrigerating Engineers, telling how a research laboratory chose Oilgear Transmissions and obtained continuous, dependable performance without delay, is another chapter in that story.

Demands for tests of materials at extreme temperatures called for equipment able to hold testing room temperatures stable at all times—usually at 70° F. below zero. It also had to refrigerate test materials as rapidly as possible. This meant a system of varying compressor speeds automatically—so as to compensate for variations in heat load.

Previous experience had shown that . . . the use of direct current motors, or variable speed drives of the belt-and-pulley type, under automatic control, was not entirely reliable and required considerable servicing.

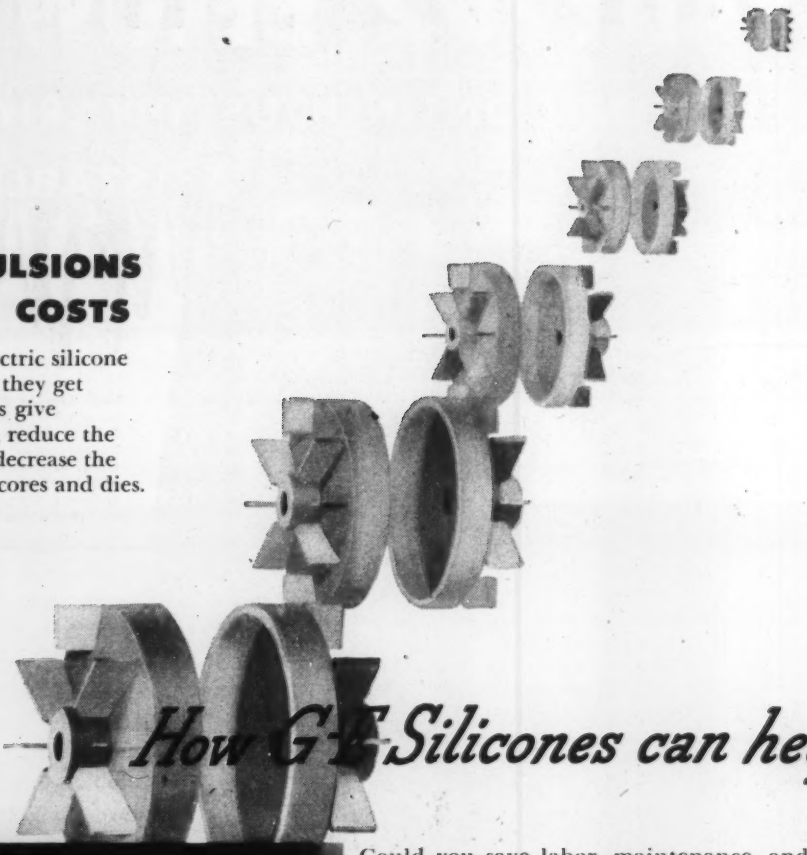
Then Oilgear Fluid Power Transmissions were adopted. These transmissions provide continuously and automatically variable output speed and maximum output torque at all operating speeds. Nearly two years' experience reveals that temperatures have been maintained within ±½° F. of the desired figure over long periods of time, that no attendant is required except for a few minutes' daily routine inspection, that the Oilgear drives are completely reliable.

Thus the evidence grows that if you are tired of machine or process drives and transmissions that don't stand up, if you want simpler, better, more productive and dependable drives, if you have problems not yet solved, it will pay you to contact Oilgear Fluid Power engineers. THE OILGEAR COMPANY, 1305 W. Bruce St., Milwaukee 4, Wis.

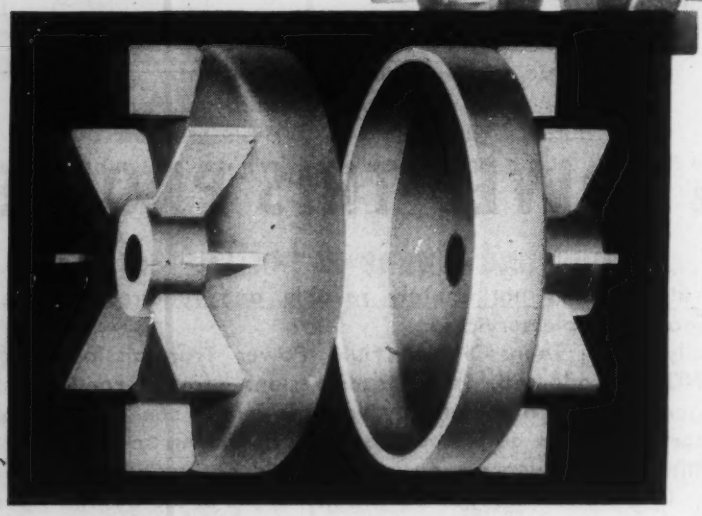
Oilgear Fluid Power

G-E SILICONE EMULSIONS CUT DIE CASTERS' COSTS

When die casters use General Electric silicone emulsions as mold release agents they get smooth castings. These emulsions give easy release with a very thin film, reduce the break-in time of new molds, and decrease the down time required for cleaning cores and dies.



How G-E Silicones can help you



Could you save labor, maintenance, and improve your manufacturing methods by using a chemically inert, temperature-resistant material? Then you'll want to explore the applications of General Electric silicones.

These amazing materials, characterized by their indifference to extremes of heat and cold, are constantly finding new uses throughout industry, extending design possibilities and facilitating production. General Electric silicone oils, for example, will not decompose in temperatures as high as 400 F. And they retain their viscosity even in cold as low as —90 F. General Electric silicone greases are proving to be superior lubricants for plug cocks and valves, because of their resistance to chemicals and heat.

General Electric silicone rubber will not soften at 350 F, or become brittle at —10 F. It can be supplied in extruded shapes, in compression-molded sheets, or in paste form. G-E engineers will modify compounds to meet specific requirements. And remember to investigate G-E silicone gum. Here's a new raw material for rubber and compound manufacturers which will permit them to produce a rubber with new standards of chemical and heat resistance.

WANT TO KNOW MORE ABOUT G-E SILICONES? Perhaps they can help with *your* production problem—or improve your products. Write for more information to: Section 35-1, Chemical Department, General Electric Company, Pittsfield, Massachusetts.

GENERAL ELECTRIC

CD49-Q1

SILICONES

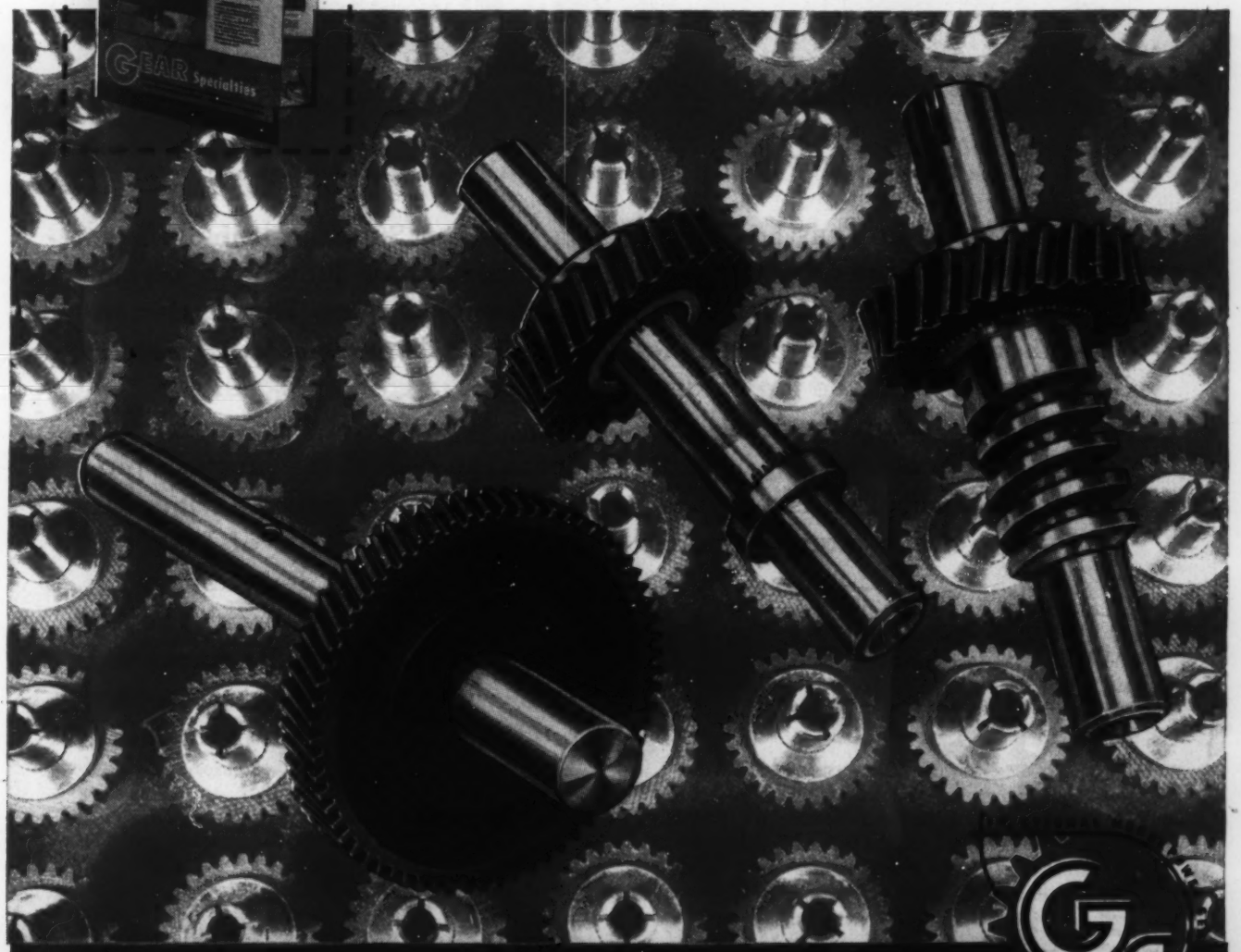
Wichita City Library

SEND FOR THIS FREE CATALOG-BULLETIN

The G.S. Gear Bulletin illustrates and describes many different types and applications of G.S. Small Gears. It offers valuable aid to anyone concerned with specifying Gears 12 D.P. and finer. Write today!

ARE YOU PAYING *TOO MUCH* FOR SMALL GEARS?

FRACTIONAL Horsepower Gearing can be *very* costly! It isn't so much the money you pay for the gears. It is rather the high price you pay in lost customers and prestige when your gears are poor in quality and lack uniformity . . when your product fails to give long, smooth, dependable service! The mass production of fine, uniform, precision-cut Small Gearing is a *highly developed specialty* of ours. Year after year, many of America's largest and most particular buyers look to us for *all* of their Small Gear needs. G. S. products are modestly priced for the greater service and satisfaction they give. Ask our competent staff for ideas, suggestions, and estimates on *your* requirements . . write today. There's no obligation.



GS

GEAR Specialties

Spurs • Spirals • Helicals • Bevels • Internals • Worm Gearing • Racks • Thread Grinding

2635 WEST MEDILL AVENUE · CHICAGO 47, ILLINOIS

MEMBER OF AGMA

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

PHOTO AND PERFORMANCE DATA COURTESY CANEDY OTTO MFG. CO.

MACHINE DESIGNERS have long recognized the advantages of *one-piece design* for cluster gears, and other integral unit parts. The Gear Shaper has made the production of such designs possible to a greater degree of accuracy, and on a more economical basis.

One-piece cluster gears, generated on the Gear Shaper, eliminate misalignment in the fitting and keying of assembled gears. The number of machining operations is decreased, and overall costs reduced.

The versatility of the Gear Shaper opens the door to the practical production of many intricate shapes... increases the scope of low-cost machining at the designer's command. Our illustrated book, "The Art of Generating with a Reciprocating Tool" will prove of interest to every production-minded design engineer.

Reciprocating Generation
THE BASIS OF UNPARALLELED GEAR SHAPER VERSATILITY
12 Variable Motions and Positions
Plus Unlimited Cutter Designs
A CUTTER THAT RECIPROCATES WITH (OR WITHOUT) ROTATION
WORK POSITIONED IN ANY PLANE ...WITH OR WITHOUT ROTARY, LATERAL OR COMBINED MOTIONS
A CUTTER SPINDLE THAT CAN BE MOVED IN AND OUT
CUTTER PROFILES OF ANY REQUIRED CONTOUR

Fellows

THE FELLOWS GEAR SHAPER COMPANY

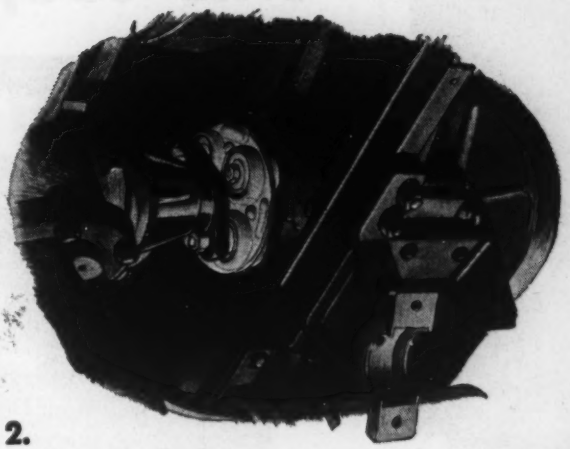
Head Office and Export Dept., Springfield, Vermont. Branch Offices: 616 Fisher Bldg., Detroit 2, 640 West Town Office Bldg., Chicago 12, 7706 Empire State Bldg., New York 1.

THE FELLOWS METHOD...MACHINES AND TOOLS FOR ALL OPERATIONS FROM BLANK TO FINISHED GEAR

Want to reap a harvest in your business?

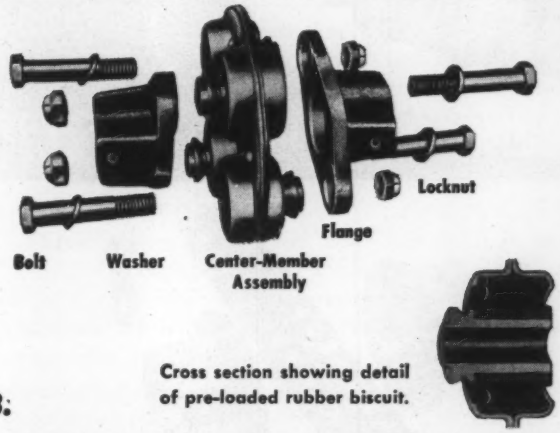
1.

Wanted: a one-man crew to harvest grain in labor-short areas. Cockshutt Plow Co., Ltd., Brantford, Ont., built such a harvesting combine. But trouble-free operation had to be assured on such vital turning parts as the shaft between transmission and differential. Needed: a flexible coupling to absorb shock and vibration, increase shaft life, yet withstand grit, chaff and moisture. Impossible?...



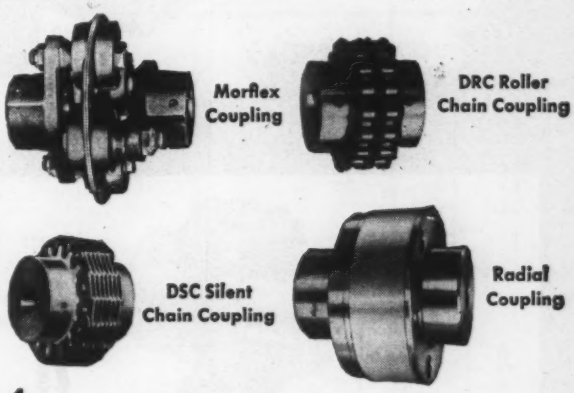
2.

Cockshutt Plow's unusual coupling need was quickly filled by Morse Morflex Couplings. Shockproof, quiet, compact—they take all the kicks the combine gives, *and compensate for misalignment.* Other Morse Couplings—Silent and Roller Chain, "Junior" and Double Morflex, Radial and Marine Morflex—are made to thresh out particular problems in *your* business. Take a closer . . .



3.

Look at the Morse Morflex Coupling and you'll see why it's such a good "hand." Employing the exclusive Morse-designed rubber biscuit assembly, it has a muscle-like flexibility that takes the wrap-up of torsional loads. Its construction eliminates metal-to-metal contact between driving and driven members, requires no lubrication, and is sealed against dust, dirt, and weather. Perhaps . . .



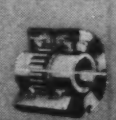
4.

You'll get plenty of bright ideas for coupling uses from a set of Morse Coupling catalogs. Address: Dept. 270, Morse Chain Co., 7601 Central Ave., Detroit 8, Mich. Or, for on-the-spot engineering advice and aid, write or wire—trained and experienced Morse Sales Engineers will call on you. Ask to see and hear more about the entire line of Morse Mechanical Power Transmission products.

MORSE

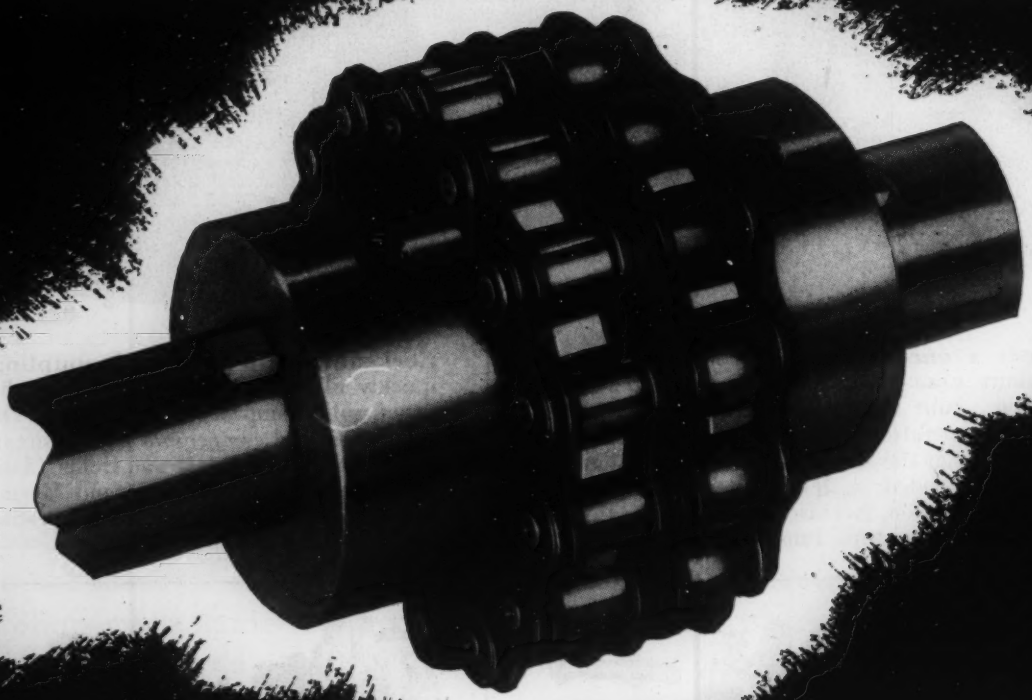
MECHANICAL POWER TRANSMISSION PRODUCTS

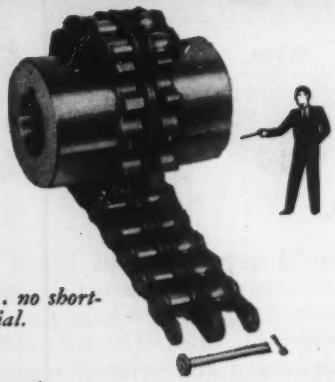
A PRODUCT OF B-W BORG-WARNER



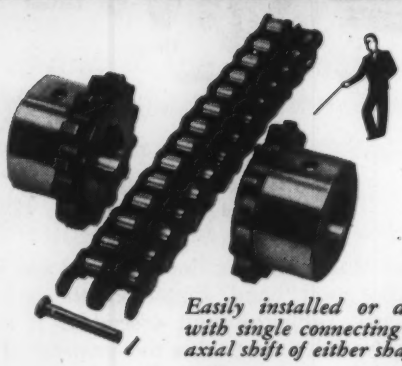
MORSE CHAIN COMPANY • DETROIT 8, MICHIGAN

This coupling gives you TRUE

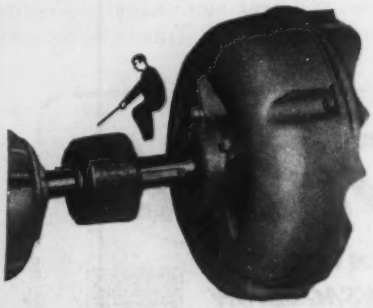




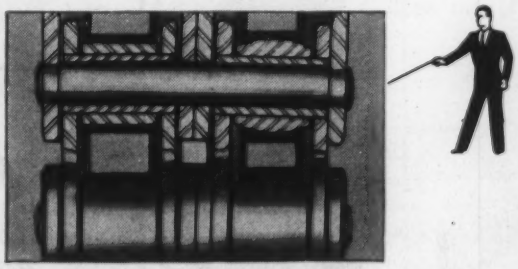
All-steel . . . no short-lived material.



Easily installed or disconnected with single connecting pin . . . no axial shift of either shaft.



Dampens transmission of pulsating loads.



Plus EXTRA flexibility . . . EXTRA shock absorption because the pins bend.

Flexibility without Backlash

BALDWIN-REX TRU-FLEX COUPLINGS

Truly flexible without backlash . . . shock absorbing . . . easily installed or removed . . . dampen vibration . . . accommodate misalignment and end play . . . long lived . . . only Baldwin-Rex Tru-Flex Couplings give you all these advantages.

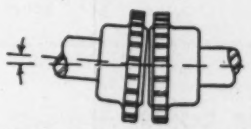
These efficient roller chain couplings are distinguished by their oversize convex rollers on one chain strand . . . an exclusive design that gives you better all-round performance, more protection and longer service. The convex rollers maintain only line contact with sprocket teeth and because of this line contact, the pins are designed to flex or bend. Thus, the couplings can accommodate misalignment and absorb greater torsional shock loads. Chains are fitted snugly to the sprocket assuring you far longer life than the "sloppy fit" of ordinary chain couplings. Backlash is completely eliminated. Tru-Flex Couplings have a constant capacity to transmit power.

There are no short-lived materials used in these couplings. Their all-steel construction assures you the maximum in service at minimum maintenance costs. They will operate efficiently under the same oil, heat or corrosive conditions as the shaft on which they are mounted.

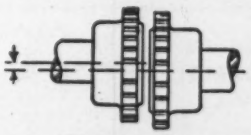
And you'll be amazed at how easily you can install or remove Tru-Flex Couplings. With their single connecting link, you merely wrap the coupling chain over the sprockets, insert the pin and secure the cotter. To remove, simply remove the cotter, withdraw the pin, and remove the chain. There is no need for an axial shift of the shaft or moving all the equipment.

For all the facts on Tru-Flex Couplings send for your copy of Bulletin No. 46-6. Write Baldwin-Duckworth Division of Chain Belt Company, 320 Plainfield Street, Springfield 2, Mass.

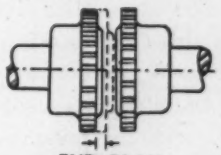
TRU-FLEX COUPLINGS ACCOMMODATE:



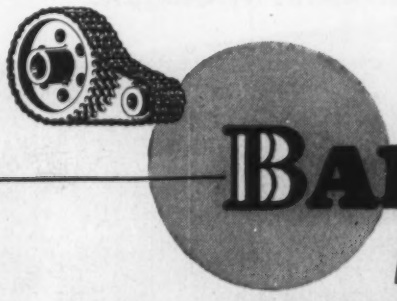
ANGULAR MISALIGNMENT



RADIAL MISALIGNMENT



END PLAY



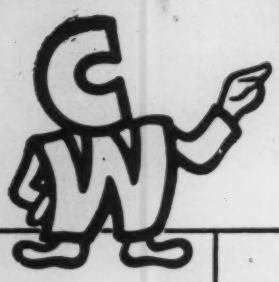
BALDWIN·REX

ROLLER CHAIN COUPLINGS

BALDWIN-DUCKWORTH DIVISION OF CHAIN BELT COMPANY

It STAYS CLEANER LONGER....

See why the



C-W SEALEDPOWER

TOTALLY-ENCLOSED....FAN-COOLED MOTOR

SAVES 80% OF MAINTENANCE COSTS

COMPARE CLEANING COSTS!

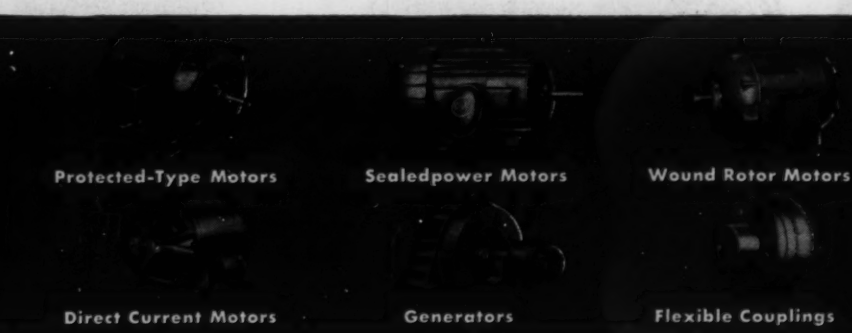
	Conventional* Fan-Cooled Motor VS C-W Sealedpower Motor — Normal (Not Extra Dirty) Service	
FREQUENCY	**EVERY YEAR** a conventional fan-cooled motor requires cleaning, in the opinion of experienced maintenance chiefs.	**ONCE EVERY 3 YEARS** is often enough for a Sealedpower motor, according to those who have had experience with it.
OPERATIONS REQUIRED	**17 OPERATIONS**—to shut down, dismantle, clean and reassemble motor. Motor must be shut down and taken out of production, for about 3 hours.	**NO NEED TO SHUT DOWN** in normal—not extra dirty—duty, no need to remove fan cowl, etc. Brushing cowl end, and cleaning outside of motor is sufficient.
TIME, LABOR COSTS	**$4.95** **3 HOURS** time, estimated by motor maintenance men, at union scale of $1.65 per hour, totals $4.95 yearly per motor, in normal service.	**14¢** **¼ HOUR** time, once every 3 years, cleans a Sealedpower motor. At $1.65 per hour, cleaning cost per year is only 14¢.
COSTS IN ABNORMAL SERVICE	**EVERY 3 MONTHS,** a conventional motor, operating where dirt or lint is excessive, should be cleaned. That requires 18 hrs. of labor at $1.65, for a total cleaning cost of $29.70 per motor, during an interval of 18 months.	**ONLY ONE** cleaning every 18 months keeps a Sealedpower motor running cool and efficiently. Only ¾ hour to remove fan cowl, brush fan and outside of motor and replace cowl. A labor cost of only $1.24 per motor.

A totally-enclosed, fan-cooled motor, of conventional design, was used for comparison

You get this *dollar-saving design* only when you specify C-W Sealedpower Motors. No other totally-enclosed, fan-cooled motor has exterior cooling, with the fan-driven airstream blowing over the finned frame, carrying dust and fumes *outside* and *away*. It beats rust and corrosion, too, because the frame is rugged *cast iron*.

RATINGS FROM 3 TO 60 HP, horizontal or vertical, with NEMA "C" or "D" flange mountings. Many ratings are stocked . . . see C-W's weekly Stock Sheet. Talk over your motor needs with a Crocker-Wheeler representative.

FOR ANY APPLICATION WHERE EXCESSIVE MAINTENANCE IS INDICATED
—specify SEALEDPOWER and SAVE



Protected-Type Motors · Sealedpower Motors · Wound Rotor Motors

Direct Current Motors · Generators · Flexible Couplings

It SKIPS SHUTDOWNS

150°o MORE COOLING SURFACE

is provided by the radiating fins, exclusive with the C-W SEALEDPOWER. Here, fluttering streamers trace the fan-driven airstream that blows dust and fumes outside and away.

CROCKER WHEELER

ELECTRIC MANUFACTURING COMPANY, AMPERE 3, N. J.

A Division of The Joshua Hendy Corporation

Branch Offices:
Boston, Buffalo, Chicago, Cincinnati, Cleveland, Los Angeles, Milwaukee, New York, Philadelphia, San Francisco, Pittsburgh, Washington, D. C.—Representatives in principal cities.

Before You Buy ANY totally-enclosed motor, be sure to read why SEALEDPOWER will prove a "maintenance miser" for you. This new booklet, "It's Different—it's a Dollar-saver," is packed with facts no savings-minded motor user can afford to overlook. Write for it.

Crocker-Wheeler Electric Mfg. Co.
Ampere 3, N. J.

Send the SEALEDPOWER Motor Booklet, "It's Different—it's a Dollar-Saver".

MD-149

Name.....

Title or Function.....

Company.....

Address.....

UNBRAKO

...proved by

EXPLANATION OF VIBRATION TESTS DEMONSTRATING THE HOLDING POWERS OF DIFFERENT TYPES OF "UNBRAKO" SOCKET SET SCREWS

Better than words, the graph of actual vibration tests quickly tells the story of the exceptional "HOLDING POWER" of the "Unbrako" Self-Locking Set Screw with the Knurled Cup Point . . . *"the screw that won't shake loose."*

Vertically, the graph is divided into increments of 30 minutes. Each bar—black for Plain Cup Point and red for Knurled Cup Point—represents a screw tested and the number of minutes at which it loosened. *The height of each black bar, therefore, is a direct measure of the length of time before the plain pointed screw shook loose.* The Self-Locking Knurled Cup Pointed Screws—indicated by the red bars—were still tight at 300 minutes.

All screws were tested under identical conditions. Rate of vibration—1750 cycles per minute . . . duration of test—until screw shook loose or tests were discontinued.

Analyzing the graph and comparing the two types of screws, we find that the most favorable test of the Plain Cup Point shows a failure at 10 minutes and 40 seconds. *No Knurled Cup Point shows signs of loosening at 300 minutes—more than 28 times the "HOLDING POWER" of the Plain Cup Point—a tremendous superiority . . . as proven by actual tests and use.*

The "Unbrako" Self-Locking Set Screws with the Knurled Cup Point can be used over and over again.

OVER 45 YEARS IN BUSINESS

STANDARD PRESSED STEEL CO.

BOX 102, JENKINTOWN, PENNSYLVANIA

BRANCHES: CHICAGO DETROIT ST. LOUIS SAN FRANCISCO

actual tests

300

270

240

120

90

60

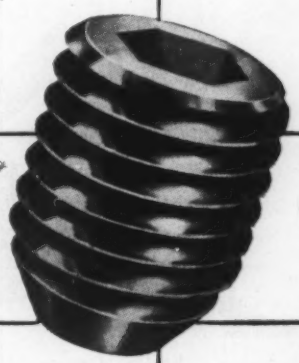
30

0

MINUTES

Because of the over-heating of the vibration machine, the tests were discontinued at 300 minutes or 525,000 cycles, but the screws were just as tight as when the tests were started.

10 MINUTES AND 40 SECONDS



UNBRAKO

PLAIN CUP POINTS

UNBRAKO

KNURLED CUP POINTS

Pat'd & Pat's Pending

Quickest way to your destination—correctly made springs—is *via Wallace Barnes*. Here you will be guided past the detours of costly extra operations or unnecessary handling. Here are many opportunities for production economies—in choice of material for easier forming—new ways of testing and inspection—automatic control of finishing operations. Wallace Barnes will help you—in advance—to avoid bad construction. Drive in, soon.

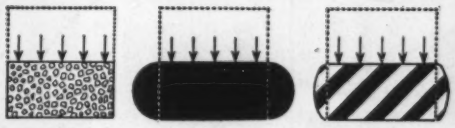
Wallace Barnes SPRINGS

SMALL STAMPINGS • WIRE FORMS • HAIRSPRINGS • COLD ROLLED SPRING STEEL

WALLACE BARNES COMPANY
BRISTOL, CONN.

DIVISION OF THE ASSOCIATED SPRING CORP.

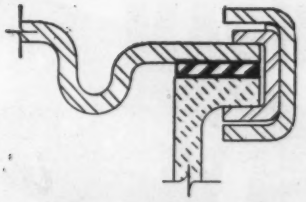
AND IN CANADA, THE WALLACE BARNES CO., LTD., HAMILTON, ONTARIO



CONTROLLED COMPRESSIBILITY

Armstrong's Cork-and-Rubber Compositions are designed especially for applications where certain properties of the various synthetic or natural rubbers are required but where their normal side flow is objec-

DATA ON SEALING MATERIAL



NO. DC-167 CORK-AND-SYNTHETIC-RUBBER COMPOSITION

Seal for watt-hour meter—Soft enough to take up the irregularities of glass cover and die-cast meter base; withstands abrasion caused by turning cover into usual attachment slots; treated to reduce surface friction.

TYPICAL APPLICATIONS

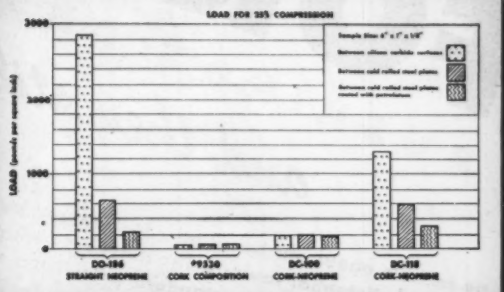
FACTORS IN CHOOSING RESILIENT GASKETS

Once a good flange or joint design has been developed, there remains the problem of choosing a specific gasket material. A review of principal factors can help narrow the range of possible choices and speed final selection.

TEMPERATURE. Constant temperatures in excess of 250° F. damage most resilient materials. Under certain conditions, however, some resilient materials may be used where temperatures exceed this limit. When temperatures fluctuate, for example, an average figure may be used as the upper limit. We suggest, therefore, that you check application details with us before you abandon the possibility of using a resilient gasket on account of temperature.

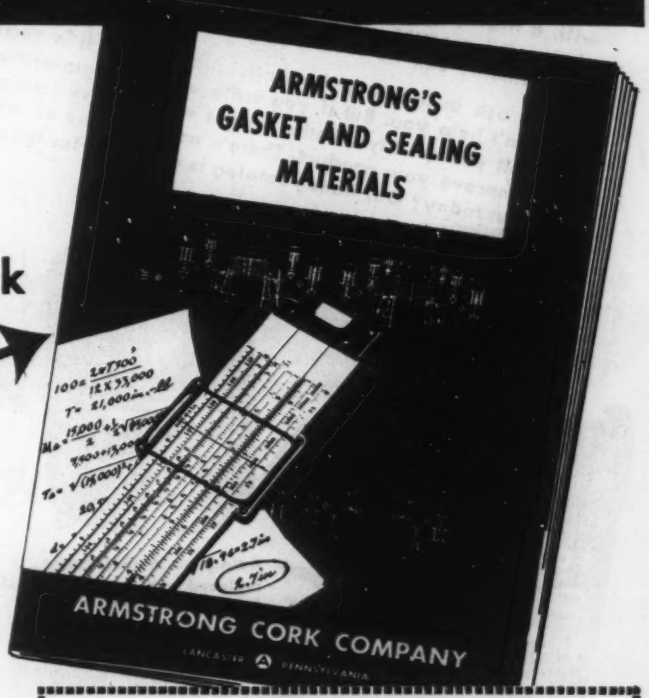
INTERNAL PRESSURE. When internal pressures are high, a tough, non-porous material should be used. Gaskets normally should be as thin as flange surfaces will permit. Special groove or flange design may be required.

10 TYPICAL DISCUSSIONS



USEFUL CHARTS

Send For Your Copy Of This Gasket Handbook



This booklet contains up-to-date data on synthetic rubber, cork-and-synthetic-rubber, cork composition, and fiber-sheet sealing materials. It suggests methods of putting Armstrong's stock materials to specialized uses in such fields as radio, electrical, automotive, petroleum, and transportation industries. Also gives materials charts, typical applications, and late government specifications.

For your free copy, fill in coupon and mail to Gaskets and Packings Department.

Armstrong Cork Co. Gaskets and Packings Dept.
5101 Arch Street, Lancaster, Pennsylvania

Please send me at once a copy of the new 24-page booklet, "Armstrong's Gasket and Sealing Materials."

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COMPANY _____

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ARMSTRONG'S

GASKETS • PACKINGS • SEALS

SPECIALS

FORMETAL

BUSHINGS AND BEARINGS

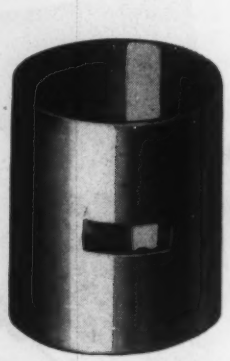
and they still cost less!

There's no miracle about our being able to give you bushings and bearings at substantial savings. The reason is—what might seem like a "special" to you is standard production with us.

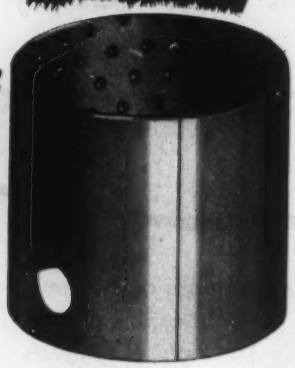
For example, in a Formetal bushing, you can have alloys with a higher Rockwell hardness without loss of machinability. Oil grooves, oil holes or cut-outs and other special requirements can be readily engineered to your exact need.

If you use bushings or bearings . . . and keep it a secret . . . we can't help you. But if you write us, our engineering staff will tell you quickly whether or not we can save you money and improve your product. There's no obligation so why not find out today? Our handy catalog is available for the asking!

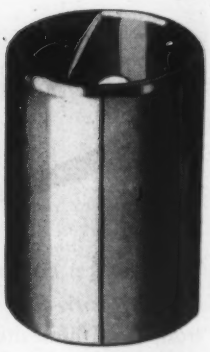
. . . TO GET YOUR PRODUCTS REALLY ROLLING . . . USE **FORMETAL** *Superformed* BUSHINGS AND BEARINGS



Auto parts manufacturer replaced ordinary bushings with Formetal Superformed Bushings. Effected annual savings of $16,800.



Auto assembly manufacturer changed to Formetal Superformed Bushings—improved performance of assembly and saved $18,600 annually.



A motor manufacturer substituted Formetal Bearings for those previously used. Result: he saves $13,800 annually.

LARGEST MANUFACTURERS OF SPACER TUBES IN THE WORLD

FORMETAL

BENDIX-SCINTILLA FLYWHEEL-TYPE MAGNETO

FOR 1- AND 2-CYLINDER ENGINES

Waterproof Coils

The moulded waterproof coil on Bendix-Scintilla Flywheel-type Magnetos is your guarantee of a steady flow of high-tension sparks, regardless of rain, spray, or other atmospheric conditions. And this dependability under adverse operating conditions is just one of the many outstanding construction features that make Bendix-Scintilla Flywheel-type Magnetos the choice of leading manufacturers. Why not see for yourself the pre-eminent fineness that is designed and built into all Bendix-Scintilla Flywheel-type Magnetos?

BENDIX-SCINTILLA BRINGS YOU ALL THESE OTHER ADVANTAGES

Easier starting . . . Lower operating cost . . . Minimum lubrication requirements . . . Moulded condenser . . . Peak efficiency at high or low speeds . . . Light in weight.

For Further Details and Suggested Applications,
WRITE DIRECT TO THE SALES DEPARTMENT

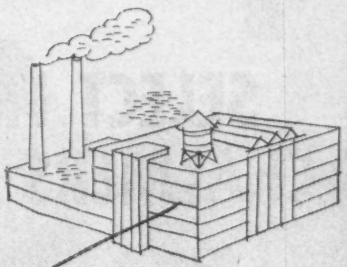
BENDIX SCINTILLA

SCINTILLA MAGNETO DIVISION of
SIDNEY, NEW YORK

Bendix AVIATION CORPORATION

assures successful operation high speed liquid seals

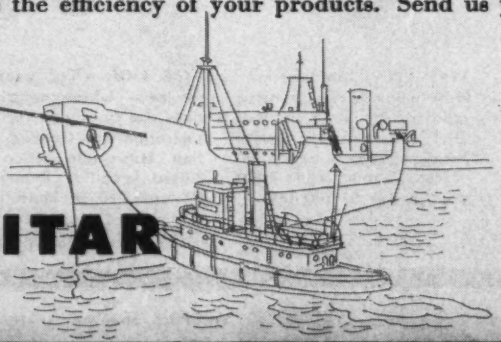
Gits Specifies Graphitar for Oilseal Assembly To Solve High Speed Sealing Problem



● Keeping the lubricating oil separated from liquids being pumped at high speeds and pressures was a problem for the Gits Brothers Manufacturing Co. of Chicago, until they specified Graphitar for the nose piece of their oil-seal assembly for pump manufacturers. Now the Graphitar seal helps *keep pumps operating smoothly* despite operating conditions of 150 psi pressure, 4000 RPM and 150°F. temperatures.

● This is another typically difficult sealing problem that Graphitar is solving in industry today. Graphitar seals seat themselves and form a drop-tight seal under conditions that many conventional seals cannot tolerate. Graphitar *does not warp or distort under heat,* it is corrosion resistant and mechanically strong. Graphitar is a carbon-graphite product that is self-lubricating and extremely light. It can be ground to tolerances as *close as .0005" in small sizes.* Our engineers may be able to suggest Graphitar applications that will improve the efficiency of your products. Send us your prints for recommendations without obligation.

Ask for your copy of the Graphitar catalog.



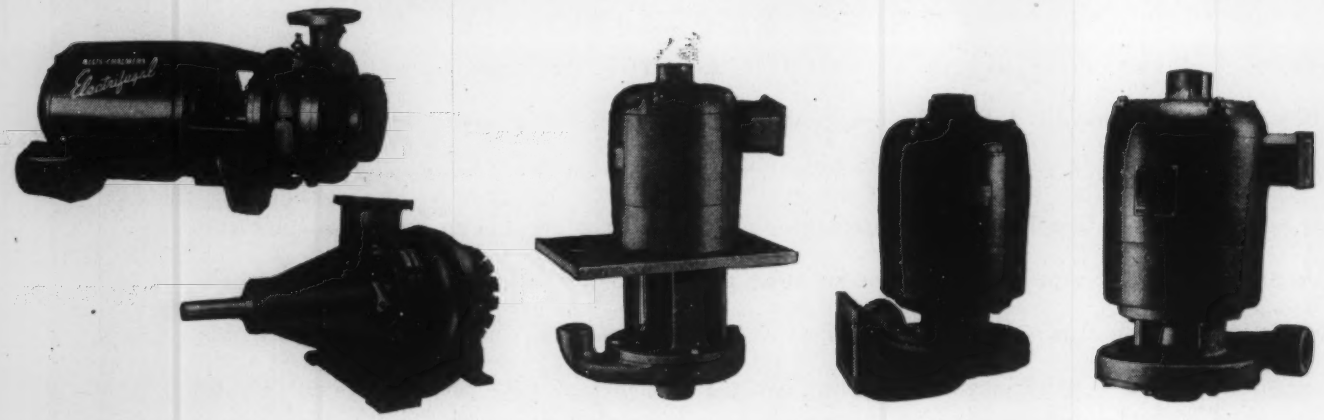
GRAPHITAR

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

ALLIS-CHALMERS OFFERS EQUIPMENT

Looking for a

SELECT FROM THE COMPLETE ALLIS-CHALMERS LINE 10 GPM TO ANY SIZE!



ELECTRIFUGAL — Sturdy package type unit. Pump brackets and flange integral with frame. Capacities 10 to 1600 gpm, heads to 525 ft. Horizontal or vertical mounting.

TYPE CW — Use wherever large amounts of suspended solids are to be circulated. Only 5 working parts! Wearing parts easily replaced. Capacities to 7000 gpm, heads to 100 feet.

TYPE RHV — For general service — where no abrasives are handled. Vertical operation with flooded suction. Has single suction enclosed impeller. Range to 97 gpm, 90 ft. head.

TYPE CR — General service pump mounts in horizontal, vertical, or angle position. Flexible mechanical seal automatically compensates for wear. Range to 80 gpm, heads to 100 feet.

TYPE CRV — For general service where no abrasives are handled. These are sealed, single suction, open impeller, sidewall mounted pumps. Range to 80 gpm, 60 ft. head.

Electrifugal, Texrope, Super-7, Texiron, Texsteel, Texdrive, Magic-Grip, and *Vari-Pitch* are Allis-Chalmers trademarks.

Texrope V-Belt Drives

Quick delivery on all standard V-belt sizes and lengths. For constant speed drives, complete line of Texiron, Texsteel, Texdrive, Magic-Grip, standard or special cast iron or steel sheaves for section A, B, C, D, and E belts. For adjustable speed drives, Vari-Pitch sheaves give 100% speed range. Vari-Pitch Speed Changers, 375% speed range.

Motors — ½ hp To The Largest

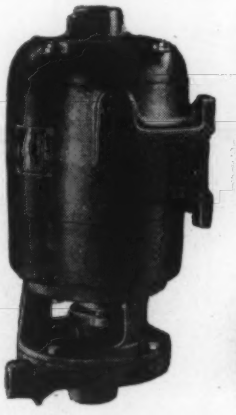
Shown are a few of the many motor types available to designers from Allis-Chalmers broad motor line. For tough operating conditions, use enclosed, fan-cooled induction motors. Dust, dirt, acid fumes, or moisture in the cooling air passes around the stator structure without coming in contact with the windings.

Sold — Applied — Serviced by Authorized Dealers, Certified Service Shops, and District Offices Throughout U. S.

ALLIS-

AID TO MACHINE DESIGNERS!

Quality Pump?

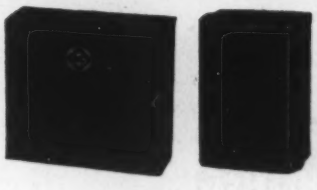


TYPE R — A general service pump of foot mounted type. Pump has shaft seal, and enclosed impeller. Sizes range to 80 gpm, heads to 100 feet.

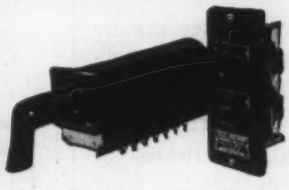
TYPE KW — A new sealless, double suction, open impeller type. Two lengths for various tank depths. Range to 97 gpm, heads to 90 feet.

TYPE HHV — Vertical, submerged, seal-less pump. Single suction. Mounting plate cast integral with adaptor. Range to 97 gpm, heads to 90 ft.

TYPE KF—Double suction, sealless, open impeller pump for handling liquids containing chips or abrasives. Range of sizes to 97 gpm, 90 ft. head.



Motor Starters



Rotary Control and Push Buttons

Controls — Any Type or Size

Across-the-line starters for a-c motors range from size 0 to 7. Also manual or magnetic, full or reduced voltage starters for any industrial application. Standard, dust-tight, water-tight, and explosion-proof enclosures. Control devices include standard and heavy duty push button stations, rotary switches, voltage regulators, contactors and relays.

ALLIS-CHALMERS, 1001A SO. 70 ST. A 2466
MILWAUKEE, WIS.

Please send me:

- ☐ Handy Guide to Electric Motors (51B6052H
- ☐ Handy Guide to Centrifugal Pumps (53B6059D)
- ☐ Handy Guide to Texrope Drives (20B6051H)
- ☐ Variable Voltage Planer Drives
- ☐ Equipment for Machine Tools (2587110)
- ☐ D-C Remote Indications and Controls (1486641)
- ☐ Coolant Circulating Pumps (5286975)
- ☐ General Purpose Motor Controls (1487132)

Name.....

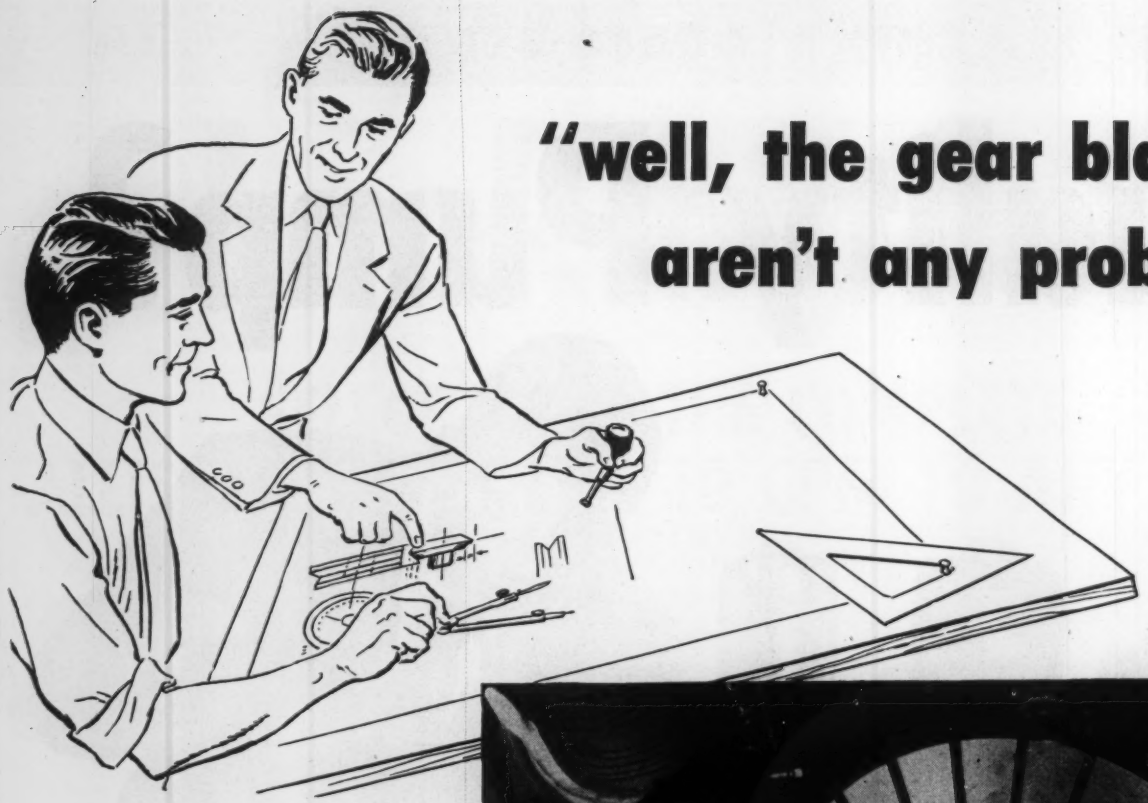
Company.....

Street.....

City.....State.....

ALLIS-CHALMERS AC MILWAUKEE

CHALMERS



"well, the gear blanks aren't any problem"

He seems pretty certain of the gear blanks he has in mind. His confidence is well placed, for he's thinking of Bethlehem rolled-and-forged blanks, which he's specified many times. He knows they're strong and tough, and he likes their moderate cost.

Another thing that appeals is the rough-machining Bethlehem does on the blanks. They reach him all cleaned up and ready for finish-machining. Saves him a step in his plant. Saves him expense.

Naturally, he's weighed his metallurgists' opinions. They've told him that the blanks have excellent grain structure, homogeneity, and high overall quality. They've told him that because of this quality, thinner sections are often possible.

If you're not using Bethlehem rolled-and-forged gear blanks, we suggest you investigate them. You'll find them perfect for spur, herringbone, bevel, and miter gears. They can be supplied in sizes from approximately 10 in. to 42 in. OD, and you can specify carbon or alloy steel. The blanks will come to you treated or untreated, as you wish.

Ask for Booklet 216. It tells about the *many* things made from Bethlehem circular blanks: gears, of course, but also crane wheels, sheave wheels, turbine rotors, flywheels, tire molds, and many other circular parts.

BETHLEHEM STEEL

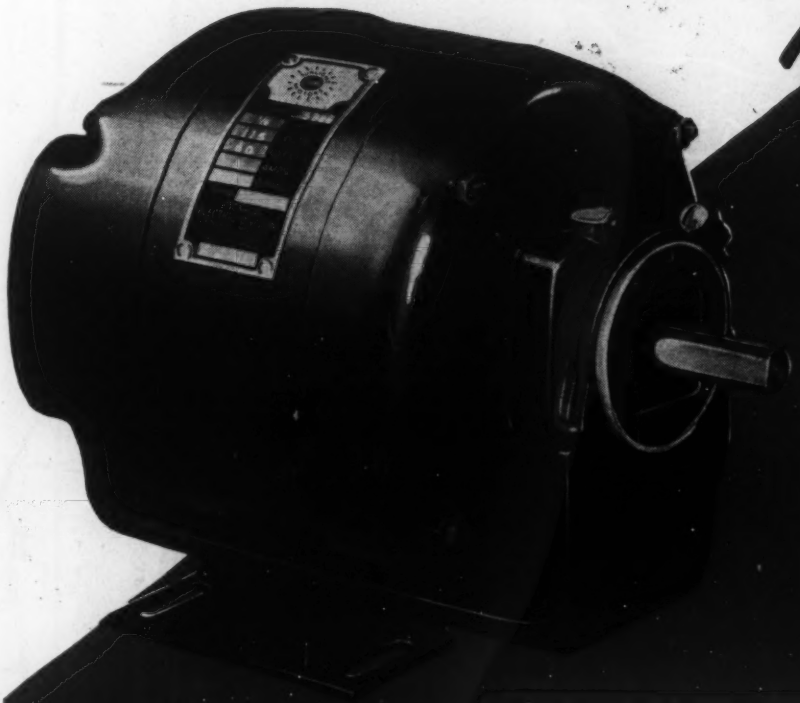
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM ROLLED-AND-FORGED CIRCULAR PRODUCTS

Now...

Top Quality Motors Available in Quantity



PACKARD SUNLIGHT MOTORS

Increased availability of Packard Sunlight Motors means increased opportunity for you to build lasting consumer satisfaction into your motor-driven appliances and equipment. A new plant and new production facilities assure a steady supply of these dependable, efficient power units for both new and old customers. Profit now from the value, the trade acceptance, the prestige that Packard Sunlight Fractional Horsepower Motors will give your products.

Packard

REG. U.S. PAT. OFF.
TRADE MARK

Packard Electric Division, General Motors Corporation, Warren, Ohio

DEPENDABLE APPLIANCE MOTORS FOR THIRTY-TWO YEARS

GIANTS

For A Giant Job!

A leading automobile manufacturer was looking for mass production facilities to quickly produce a new type of steel body . . . They called Brandt.

Brandt's flexible mass production facilities went into action. From batteries of giant presses right down to the most minute part, Brandt's men and machines met assembly line schedules.

This giant automotive job . . . now underway . . . is still another example of Brandt's ability to engineer a giant mass production job to meet exacting specifications and rigid delivery schedules.

WELDMENTS & FABRICATION
HEAVY STAMPINGS

when it's gotta fit . . .

BRANDT BALTIMORE *Measures up*

CHARLES T. BRANDT, Incorporated
1700 RIDGELY STREET, BALTIMORE 30, MD.

SERVICE CONDITIONS	TYPE OF PACKING		
	LEATHER	SYNTHETIC RUBBER HOMOGENEOUS	SYNTHETIC RUBBER FABRICATED
Oil	G	G	G
Air	G	G	G
Water	G		G
Oxygen	G		X
Steam			G
Some Solvents			G
Mild Acids			
Mild Caustic			
Resistance to Hea			F.
Resistance to Co			F.
Rotary Motion			
Reciprocating Mot			
Metal finishes (Mi			
Types of Metal			
Back support clearance			
Resistance to cold flow			
Friction (coefficient)			
Resistance to Abrasion			
Pressures, p.s.i. (Max.)			

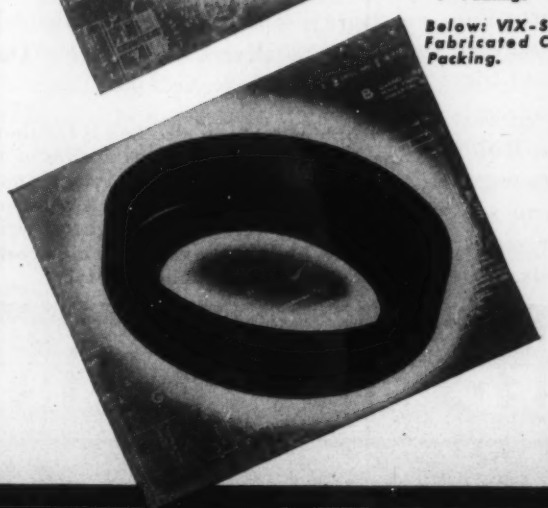
*Chrome-plated steel and desired hard, sm th surfa

AIR G=GOOD
X=DO NOT RECOMMEND P=POOR

This may help you answer- "WHAT PACKING TO USE?"

Upper photo: VIX-SYN Homogeneous "V" Packing.

Below: VIX-SYN Fabricated Cup Packing.

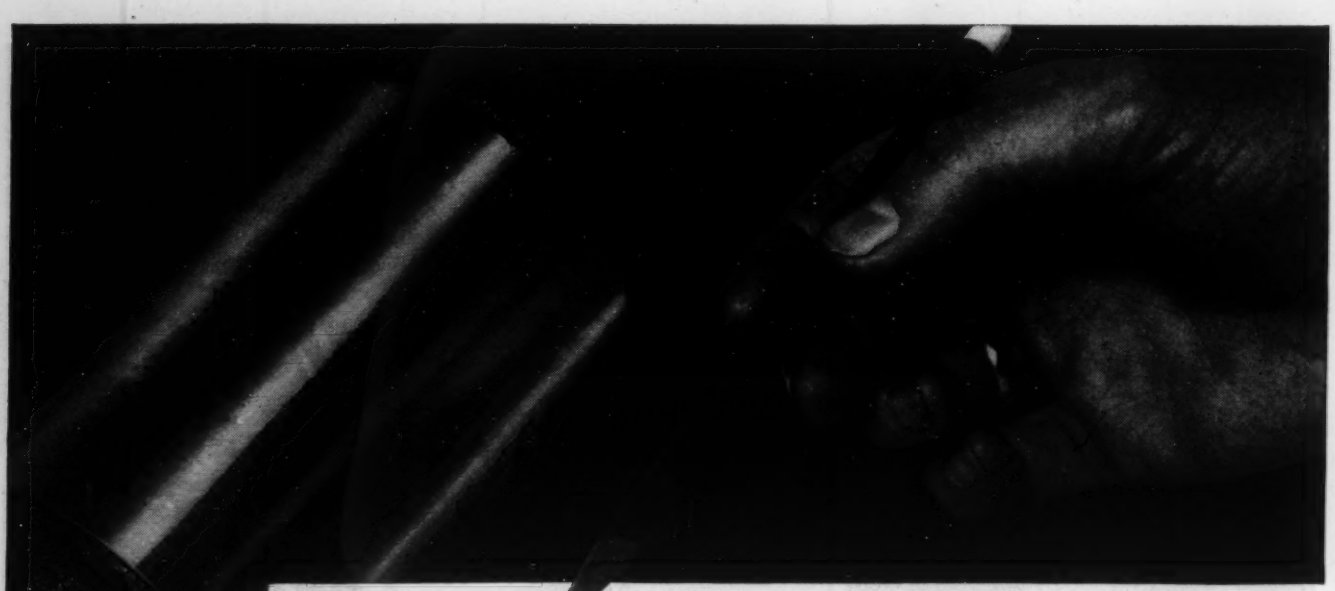


THAT'S an important question—one which must be answered correctly if your hydraulic or pneumatic devices are to function properly.

There are no positive rules—if there were, it would be easier. No two installations are exactly alike, but there are general rules which every design engineer should know . . . such information as where to use, or not to use, various types of packings, including leather and synthetic rubber. We supply both, and will make an impartial recommendation, based on your particular requirements.

As a general guide—but not an over-all rigid rule—we have reprinted a recent HOUGHTON LINE article containing a table showing what may be expected from each type of packing. A hint of that table is shown above. If you would like a copy, please write Hydraulic Department, E. F. HOUGHTON & CO., 303 W. Lehigh Ave., Phila., Pa.

HOUGHTON'S VIM LEATHER and VIX-SYN PACKINGS



10 lbs. = 10 h.p.

THESE ROBBINS & MYERS HIGH-FREQUENCY MOTOR PARTS ARE SCARCELY LARGER THAN YOUR HAND!

Smaller Size. Lighter Weight. Better Performance. R & M High-Frequency Motor Parts can be the economical answer to *all three* of these modern problems. Here's an example—a compact drive for high-speed precision grinders.

IT PAYS TO ASK QUESTIONS . . . A *conventional* 10 h.p. motor formerly was used, with a step-up belt drive to the spindle. This arrangement was both bulky and hazardous—and maintenance and slippage were aggravated by the short centers and high speed. Why not a *built-in,* direct motor drive? *Well, why not?* It's questions like this that start progress!

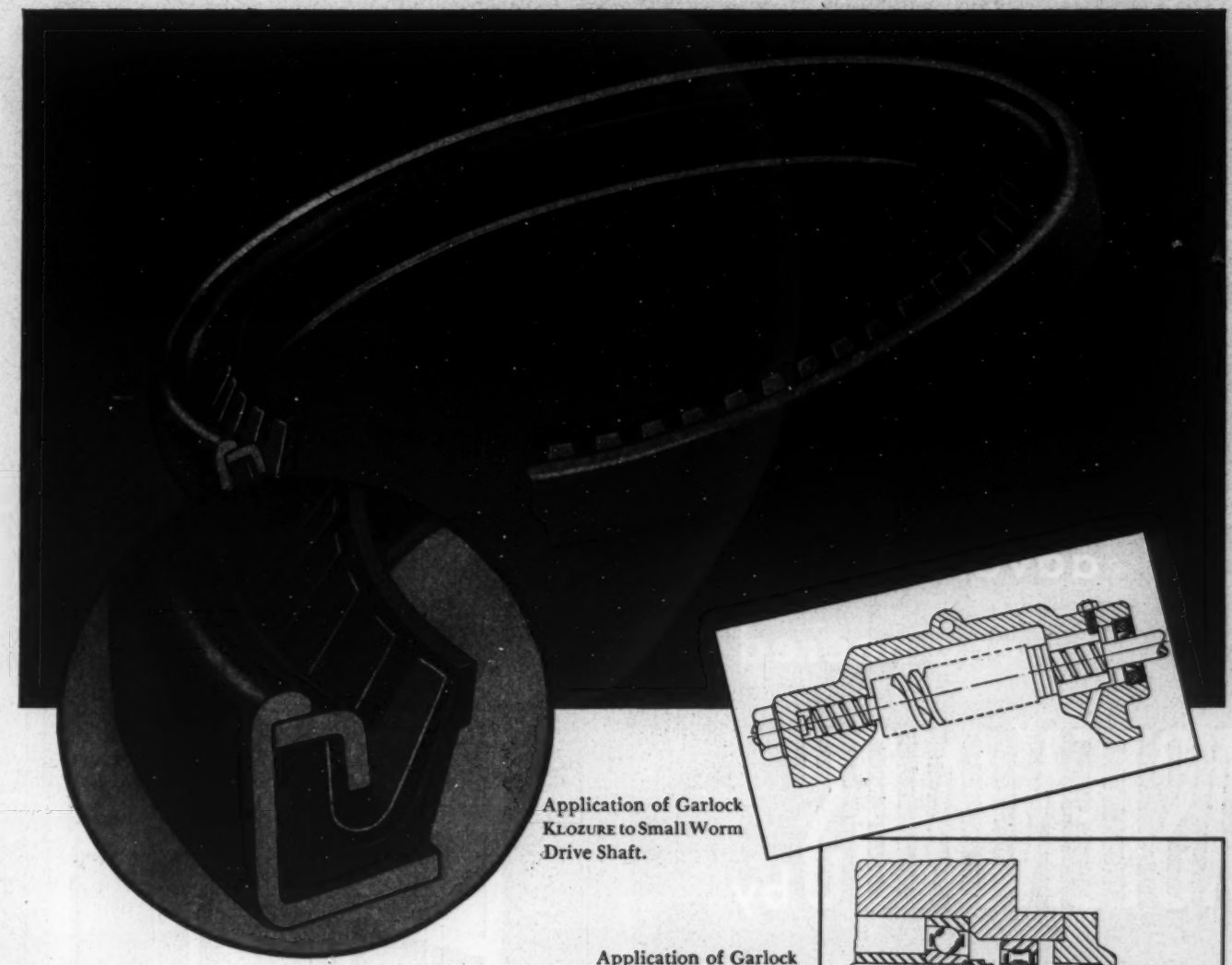
NOTE THESE COMPARISONS . . . So, Robbins & Myers *powering specialists* were called in, and the motor parts you see here were developed. Where the previous motor weighed about 120 pounds, *this* rotor-stator weighs but 10. In space, the former motor occupied some 2100 cubic inches; the new elements *only* 54. Use of high-frequency current provides the necessary spindle speed. And the drive is safe—*entirely enclosed*—with no slippage to jeopardize accuracy.

YOU, TOO, CAN PROFIT . . . If *you* are designing or redesigning to make your products better, *easier to sell,* call in Robbins & Myers. Fifty years of powering progress is yours for the asking. Address *Robbins & Myers, Inc., Motor Division, Dept. E-19, Springfield 99, Ohio.*

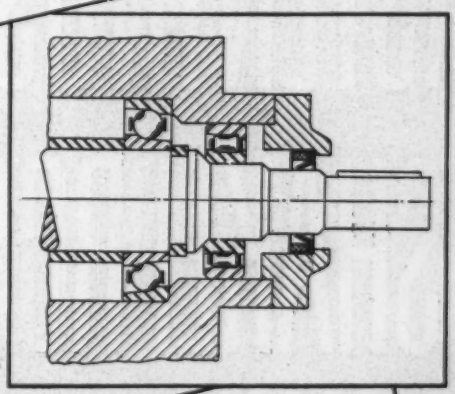
● Robbins & Myers also builds fractional and integral motors of all types in sizes to 30 h.p.; motor-generator sets to 5000 watts; and induction-type "Uni-Verters" to 15 KW for converting 60-cycle current into higher frequencies. Millions of things in everyday use are dependably powered by Robbins & Myers.

BUILD IT LIGHTER, SMALLER, BETTER-LOOKING, WITH

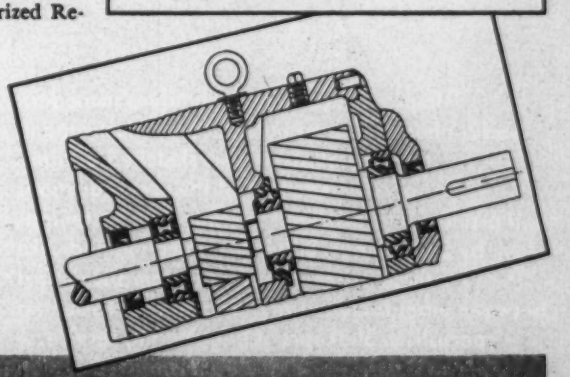
R & M MATCHED MOTOR PARTS



Application of Garlock KLOZURE to Small Worm Drive Shaft.



Application of Garlock KLOZURE to Piston-Type Pump Drive.



Application of Garlock KLOZURE to Double Reduction Motorized Reducer.

A Superior Oil Seal

The new Garlock Models 53 and 63 KLOZURE Oil Seals are constructed with light, uniform and positive spring loading for extreme sensitivity and flexibility. They seal bearings efficiently at high or low shaft speeds, even on shafts having considerable "whip" or lateral movement. The exclusive sealing element resists heat and oil, has a low coefficient of friction and is tough, durable and resilient. Write for KLOZURE catalog.

THE GARLOCK PACKING COMPANY
PALMYRA, N.Y.
In Canada: The Garlock Packing Company of Canada Ltd., Montreal, Que.

Garlock KLOZURE*

*REG. U. S. PAT. OFF.

the new

RADIO-PHONOGRAPHS

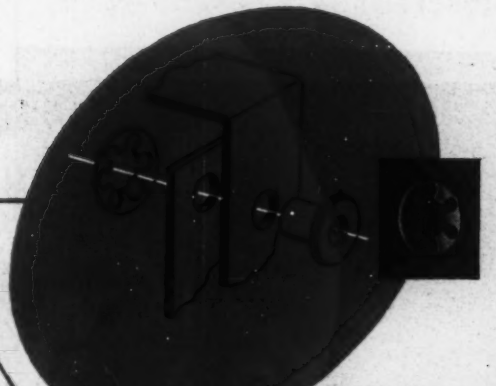
demonstrate the advantages of engineered

FASTENINGS

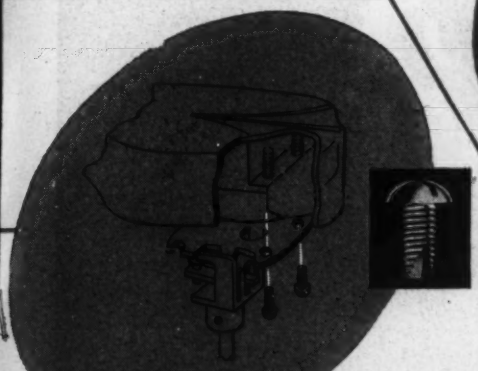
by

SHAKEPROOF

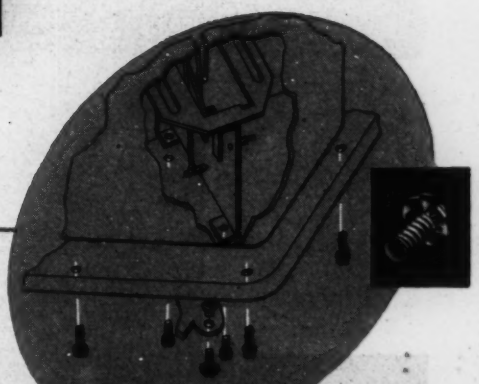
Improved fastening techniques in modern radio-phonograph manufacture, as illustrated in the typical assemblies sketched at right, are specific examples of the cost reductions and product improvements possible with Fastenings by Shakeproof. Better fastening methods like these are the result of cooperative effort between manufacturers and Shakeproof fastening specialists. Shakeproof engineering service... the same design and development cooperation that produced these improved fastening techniques... is available to all manufacturers on request. Write today!



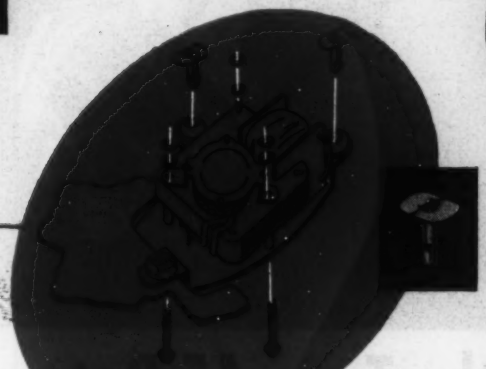
At the hinges, Shakeproof Springrip Washers simplify assembly and reduce production costs.



Type 23 Shakeproof Thread-Cutting Screws for die-castings hold the delicate sound pickup mechanism secure against constant vibration.



SEMS-by-SHAKEPROOF with both Thread-Cutting Screws and standard machine screws lock the record changer in place on the base plate.



Record changer motors are assembled securely with SEMS-by-SHAKEPROOF and Lock Washers and are mounted with cost-reducing Snap Fasteners.

WRITE FOR SAMPLES...

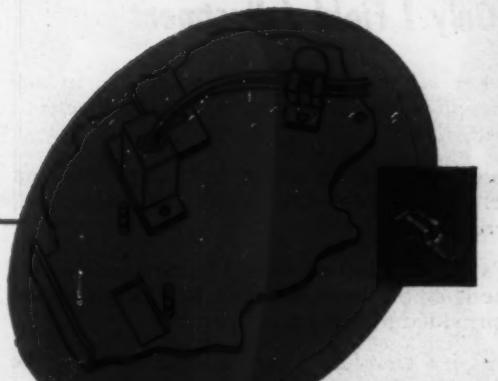
SHAKEPROOF inc.

Lakeside

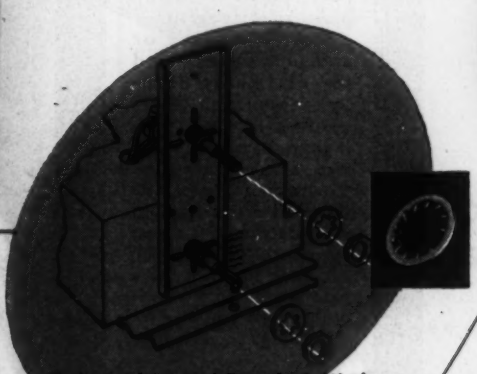
Manufacturers

2501 NORTH KEELER AVENUE

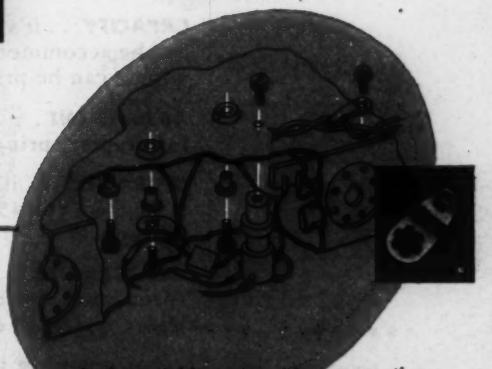
CHICAGO 39, ILLINOIS



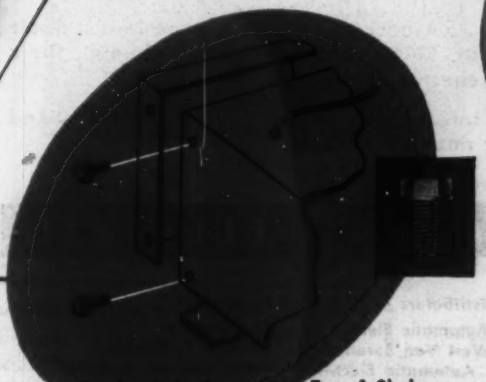
Wiring is held near place and protected [illegible] with easy to install, economical Shakeproof Speed Clips.



Shakeproof Internal Type [illegible] Washers hold the switch and volume tone control assembly [illegible] through countless on-off operating cycles.



In the variable gang condenser mounting, Shakeproof Locking Terminals and SEMS-by-SHAKEPROOF assure tight, efficient electrical connections.



In chassis back assembly, Type 1 Shakeproof [illegible] Screws eliminate the need for tapping operations or nuts.

new!

the Type 45 Rotary Switch

70 Steps a Second Speed
Up to 10 (or more) Bank Levels
Only 1 Field Adjustment

For *all* the features you want . . . in *any* remote-control application . . . look to Automatic Electric's Type 45 Rotary Switch!

SPEED . . . it's faster! It carries 10 wipers at 70 steps a second on 46 volts d.c. self-interrupted, or at 35 steps a second, externally interrupted.

CAPACITY. . . it's greater! Ten or more 25-point bank levels can be accommodated on the same frame, and single ended wipers can be provided for 50-point operation.

ADJUSTMENT . . . it's simpler! A rare readjustment of the interrupter springs is all that's normally required.

OPERATION . . . it's smoother! With an even load on *all* contacts, the Type 45 runs without galloping; there's no chatter or bounce.

ADAPTABILITY. . . it's more useful! With more levels, faster speed and 25- or 50-point operation, it's suitable for a wider variety of control applications.

For complete information on this switch that's new and better, write for our new circular.

the Class "B" Relay

Here's a new relay, too, that can be used for ordinary relay service—opening, closing or switching circuits—and for extremely high-speed operation. Independently operating twin contacts assure perfect contact operation. Contact points are dome-shaped to maintain uniformly low contact resistance. They may be arranged in one or two pile-ups with a maximum of 16 contacts on 13 springs in each pile.

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In Canada: Automatic Electric (Canada) Limited, Toronto

Wichita City Librar

enclosed gear drives...

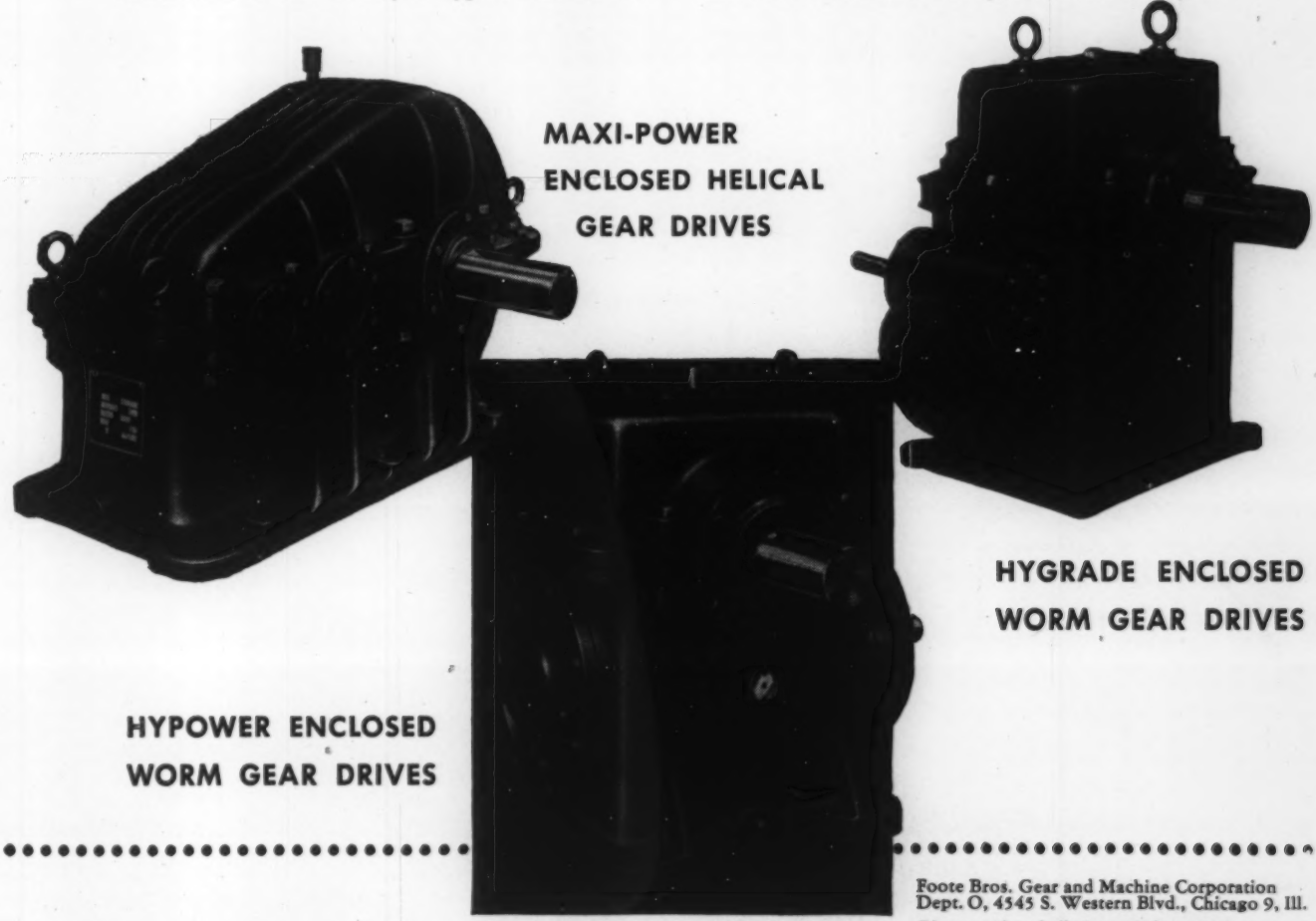
for every industrial need!

Foote Bros. Hypower Worm Gear Drives, both horizontal and vertical types, offer new economies in space, weight and cost. Increased load-carrying capacity is accomplished by a revolutionary technique in generating gears. The oil bath is cooled by passing a high velocity stream of air through an air channel cylinder immersed in the bath. This provides greatly increased thermal capacity.

Foote Bros. Hygrade Worm Gear Drives are available in a wide variety of types. This line is newly designed and includes sizes and ratios to meet practically any requirement.

Foote Bros. Maxi-Power Helical Gear Drives are available in single, double and triple reductions. This newly developed line assures maximum performance made possible by the latest in engineering development and by improved methods in manufacture.

Regardless of what your requirements in gears or enclosed gear drives may be, call on Foote Bros. There is a sales office or representative near you.



MAXI-POWER ENCLOSED HELICAL GEAR DRIVES

HYGRADE ENCLOSED WORM GEAR DRIVES

HYPOWER ENCLOSED WORM GEAR DRIVES

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
Dept. O, 4545 South Western Boulevard • Chicago 9 Illinois

Foote Bros. Gear and Machine Corporation
Dept. O, 4545 S. Western Blvd., Chicago 9, Ill.

Please send me bulletins or information on

- ☐ Hypower Enclosed Worm Gear Drives
- ☐ Hygrade Enclosed Worm Gear Drives
- ☐ Maxi-Power Enclosed Helical Gear Drives

Name.....

Company.....

Address.....

City.....*State*.....

Who said it costs more

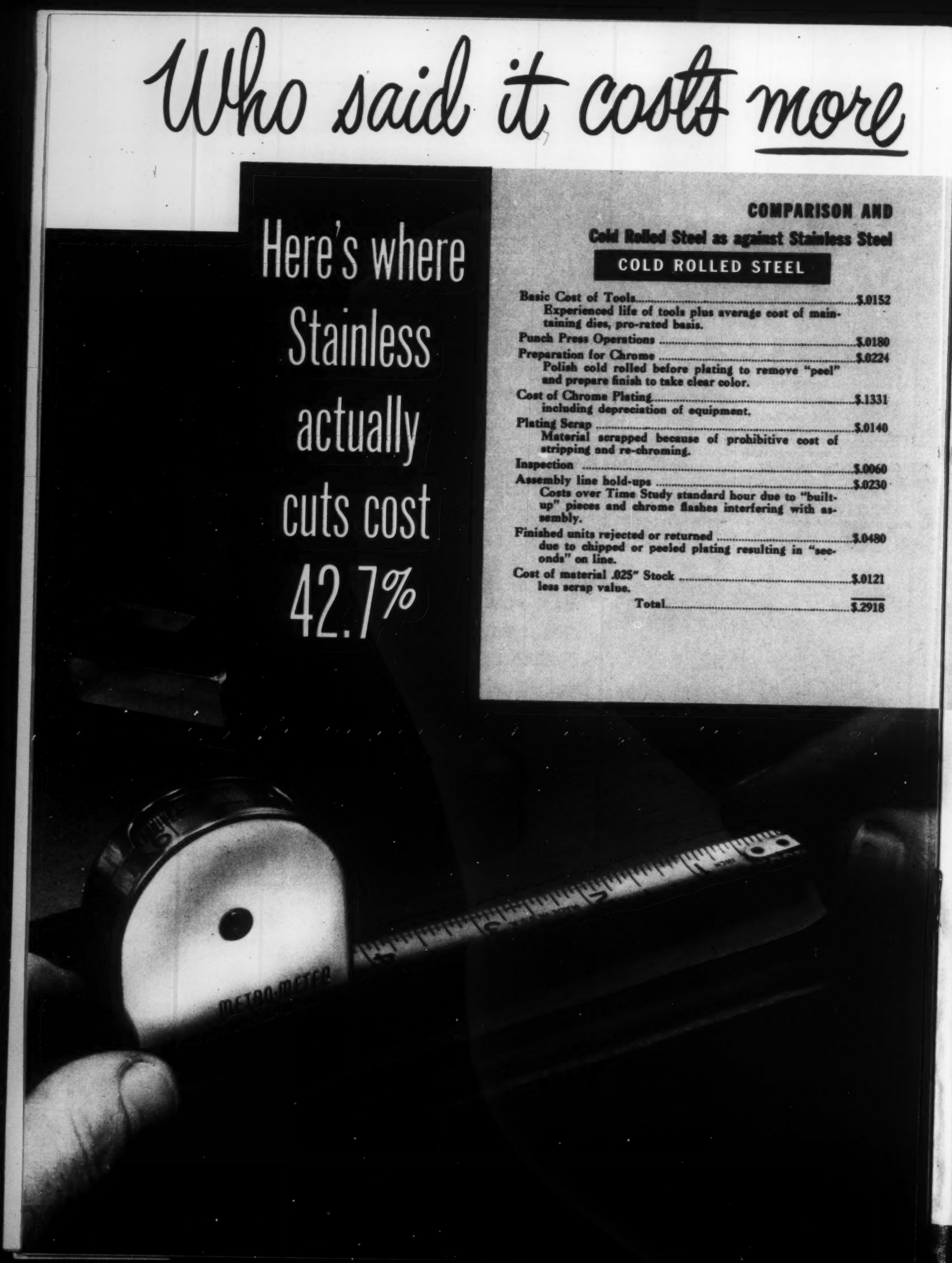
Here's where Stainless actually cuts cost 42.7%

COMPARISON AND

Cold Rolled Steel as against Stainless Steel

COLD ROLLED STEEL

Basic Cost of Tools. Experienced life of tools plus average cost of maintaining dies, pro-rated basis.	$.0152
Punch Press Operations	$.0180
Preparation for Chrome Polish cold rolled before plating to remove "peel" and prepare finish to take clear color.	$.0224
Cost of Chrome Plating including depreciation of equipment.	$.1331
Plating Scrap Material scrapped because of prohibitive cost of stripping and re-chroming.	$.0140
Inspection	$.0060
Assembly line hold-ups Costs over Time Study standard hour due to "built-up" pieces and chrome flashes interfering with assembly.	$.0230
Finished units rejected or returned due to chipped or peeled plating resulting in "seconds" on line.	$.0480
Cost of material .025" Stock less scrap value.	$.0121
Total	$.2918



to use Stainless Steel?

ANALYSIS OF COSTS

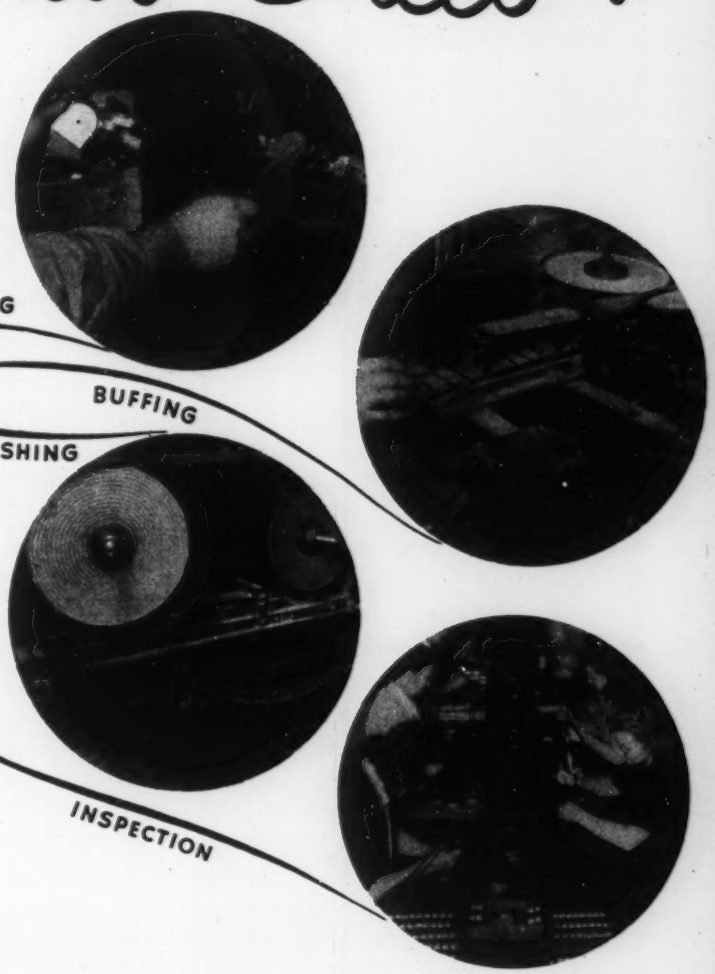
as experienced by Dart Mfg. Co., Mason, Mich.

STAINLESS STEEL

Basic Cost of Tools — Experienced life of tools plus average cost of maintaining dies, pro-rated basis.	$.0334
Punch Press Operations	$.0180
Polish and Buff — including depreciation of equipment and re-running of faulty buffing.	$.0512
Inspection	$.0060
Cost of Material .020" Stock less scrap value.	$.0584
Total	$.1670

Cold Rolled Total Costs . . . . . $.2918
Stainless Total Costs 1670
Actual Experienced Savings . . . . . $.1248 per case

Percentage Reduction in Cost 42.7%



THE "Metro-Meter" is a little device you'll soon be seeing a lot more of. It's a dial-reading steel rule with built-in scribe that men just naturally "take to" because it's practical, obviously useful, and, encased in Stainless Steel, is permanently good looking.

It's the case we want to talk to you about. Originally it was made of cold rolled carbon steel, chrome plated. The steel, itself, was inexpensive. But by the time it was prepared for plating, and plated—after the costs for rejections and returns due to over-plating, under-plating, chipping and peeling were added —each case cost a little over 29 cents.

By using lustrous satin-finish Stainless Steel in place of cold rolled carbon steel, however, all plating costs as well as rejections and returns were eliminated. Even though the initial cost of the Stainless Steel used was about five times that of the carbon steel formerly used, the final *finished* cost in Stainless was exactly 16.7 cents per case—a saving of almost 12½ cents each, which means a 42.7% reduction in cost.

What is more, with the magic word "Stainless" now stamped on the case, an almost irresistible plus has been added. Sales for the "Metro-Meter" which formerly had been good, immediately became considerably better. Thus, Stainless has done here what it has done for many other products — improved appearance, increased durability and reduced sales resistance. And in this instance, it has actually reduced costs as well. In short, a product made of Stainless Steel does *not* necessarily cost more—it only looks as though it did.

. . .

We would be glad to have the opportunity to show you where U·S·S Stainless Steel can be applied to improve YOUR product — to increase its desirability — and, more often than you may expect, to reduce its cost as well.

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
CARNEGIE-ILLINOIS STEEL CORPORATION, PITTSBURGH & CHICAGO
COLUMBIA STEEL COMPANY, SAN FRANCISCO · NATIONAL TUBE COMPANY, PITTSBURGH
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM
UNITED STATES STEEL SUPPLY COMPANY, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

United States Steel Corporation Subsidiaries
Room 2061 Carnegie Building, Pittsburgh 30, Pa.

☐ Please send me the new book, "An Introduction to U·S·S Stainless Steel."
☐ Please have a Stainless representative call on me.

Name.....

Position.....

Company.....

Address.....

City..... Zone.... State.....

USS

U·S·S STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

UNITED STATES STEEL

Exceptional Opportunities for DESIGN ENGINEERS

Right now—in the engineering department of the Boeing Airplane Company in Seattle, Washington—are openings for graduate (or the equivalent) aeronautical, mechanical, electrical, and civil engineers. For servo-mechanism designers and analysts there are unusual opportunities.

At Boeing your engineering skill and imagination will be applied to the most advanced military and commercial types of aircraft. The work involves all phases of aircraft design, from the detailing of small parts to the layout of major components, stress analysis, weight control, vibration and flutter analysis, research, development, and all associated engineering work required for completion of the design of the final product.

There's a future for you at Boeing where the current backlog of business totals more than $400,000,000. Outstanding engineering research facilities are available to you. Your associates will be the men who have contributed to Boeing's reputation for leadership in aviation research, design and engineering.

To all these advantages that Boeing offers you, add the fact that living is pleasant in the Pacific Northwest. No extremes of heat and cold. A wide variety of recreation is available the year round—fresh and salt water sailing and fishing, skiing, golf, and mountain climbing.

Similar openings are available in the Boeing-Wichita, Kansas plant. Inquiries indicating a preference for Wichita assignment will be referred to the Wichita Division.

For an illustrated brochure, "As the Twig is Bent," on Boeing engineering, and additional information about the opportunities discussed here, write "Personnel Office, Engineering Division, Boeing Airplane Company, 7753 E. Marginal Way, Seattle 14, Washington."

ANSWERING YOUR QUESTIONS

1. What about housing? *Recent new employees have had no difficulty. Our Personnel Unit will give you all possible assistance in finding suitable housing.*
2. What are opportunities for advancement? *Opportunities in all engineering units are virtually unlimited and depend primarily on training, ability and application of the individual.*
3. Does Boeing need men with advanced training? *Definitely yes. Men with advanced training and degrees are very much in demand and command correspondingly higher starting wages.*
4. What are the working hours? *Normally an eight hour day and five day week—8:00 to 4:30 daily.*
5. Is there a formal school or training program? *New engineers are normally placed in a group commensurate with their qualifications. A short training program carried on concurrently with design assignments is given for familiarization with Boeing procedures and practices.*

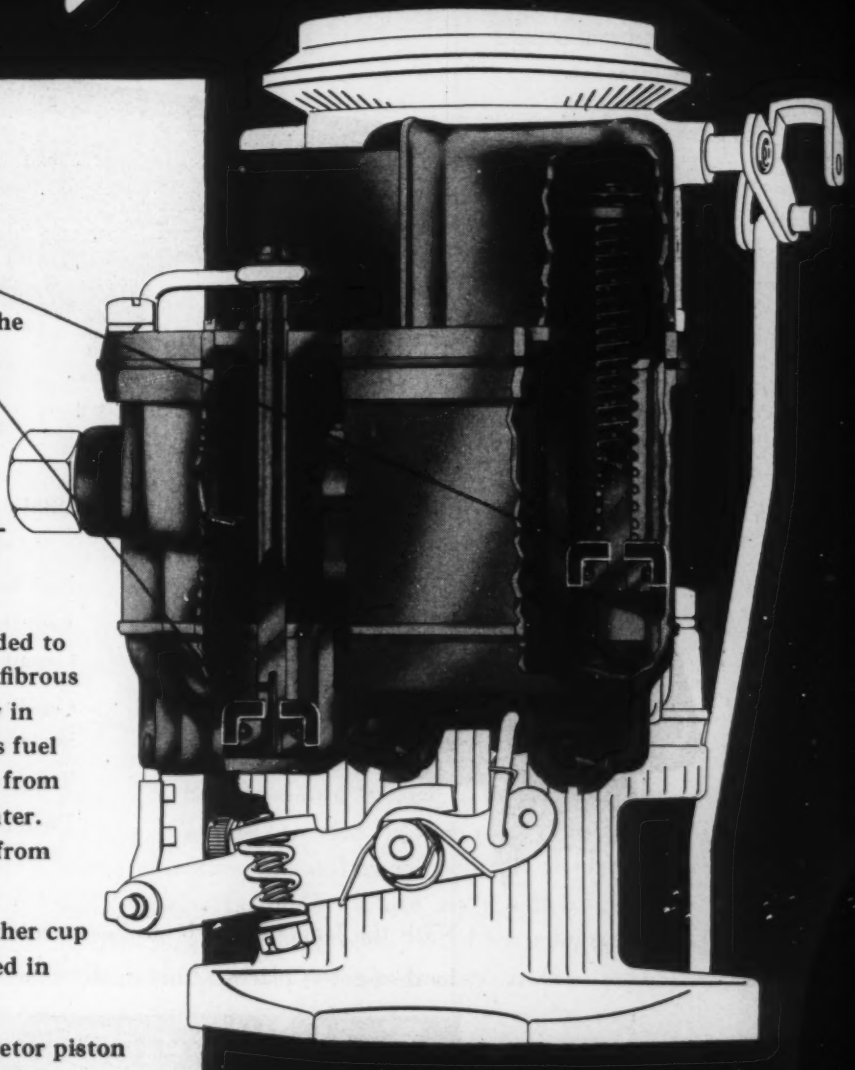
ADDED ADVANTAGES OF WORKING AT BOEING

1. Two weeks vacation with pay.
2. Ten days sick leave per year—if necessary.
3. Low cost group medical plan.
4. Low cost accident and health insurance.
5. Unusually attractive group life insurance.

For the Air Force, Boeing is building the B-50 bomber, XB-47 jet bomber and C-97 transport; for the Army, the L-15 liaison plane; and for six major airlines, the twin-deck Boeing Stratocruiser.

BOEING

it's little things that count



Like that little squirt of gasoline, when you want quick starting and fast pick-up. And the little piston pump packing which helps you get it. In Stromberg carburetors (made by Bendix Aviation Corp.), special care is taken to assure complete dependability of *every* component part. In model BXVD-3, for instance, two leather cup packings are used—one on the dash pot piston and the other on the pump piston.

These cup packings must be accurately molded to size; they must *stay* wrinkle-free; and their fibrous texture must have that tightness found only in prime calfskin. These cups must not by-pass fuel or become logged; they must neither shrink from heat nor freeze to their cylinder walls in winter. Their leather tannage must not deteriorate from contact with oils or gasoline.

Non-deteriorating *chrome* tanned Sirvis leather cup packings, made by Chicago Rawhide, are used in thousands of Stromberg carburetors.

Chicago Rawhide engineered the first carburetor piston pump packing to deliver satisfactory performance. Today, they are used in many leading makes. Because of constant research and product development, precise laboratory control, highest standards of leather quality, and exceptional care in every phase of production, Chicago Rawhide's Sirvis leather piston pump packings continue to be the most dependable.

CHICAGO RAWHIDE MANUFACTURING CO.
1304 Elston Avenue Chicago 22, Illinois

for assured performance

in your leather applications—whether in connection with oils, grease, water, or air, under high, low or static pressures—specify SIRVIS. Your inquiries will be promptly answered.

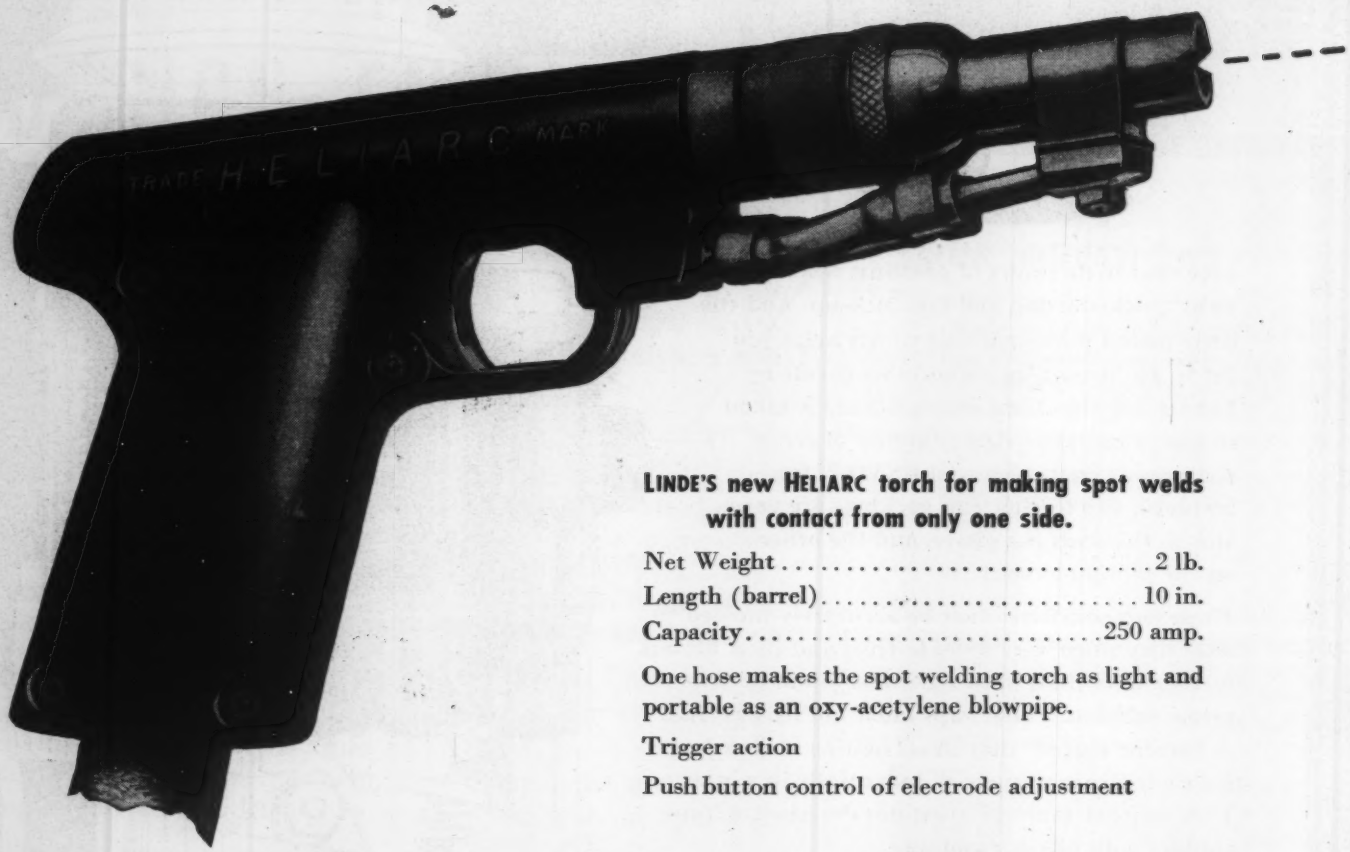
SIRVIS

MECHANICAL LEATHERS

OUR 70th YEAR OF INDUSTRIAL SERVICE

OTHER C R PRODUCTS
PERFECT Oil Seals
SIRVENE Synthetic Rubber

How would you make SPOT WELDS



LINDE'S new HELIARC torch for making spot welds with contact from only one side.

Net Weight ..... 2 lb.
Length (barrel) ..... 10 in.
Capacity ..... 250 amp.

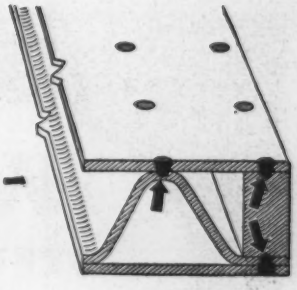
One hose makes the spot welding torch as light and portable as an oxy-acetylene blowpipe.

Trigger action

Push button control of electrode adjustment

With the HELIARC torch on the assembly line, you can easily make spot welds in those hard-to-get-at places. Other applications are just as easy.

IN PLACES LIKE THESE?



Full Scale

"HELIARC" TORCH SPOT WELDING can do it easily and quickly

Torch spot welding is a new use for inert-gas-shielded arc welding that fills a long-felt gap in sheet metal assembly methods. Spot welds are made by a light pistol-grip torch that requires access to the work from only one side.

Does many jobs

You can use this new HELIARC torch for many types of spot welding work. It is especially useful where the structure is large or of complicated shape because welding is done from one side and no forging pressure is required. You can spot weld ducts, tubes, containers, brackets, handles and many other assemblies. Mild steel, low alloy or stainless steel .030 to .064 in. thick are the metals that can now be welded. Not only can you join sheets of these metals in one to two seconds per spot, but you can also join a sheet of metal to underlying material of any thickness. Thus, corrosion resistant sheets can be spot welded to mild steel plate to provide cladding.

Easy to use

It's no trick to weld with the pistol-grip HELIARC HW-8 Spot Welding Torch. Just press the "muzzle" of the "gun" against the work and pull the trigger.

Low-cost power equipment is another feature of this process that makes it attractive. A regular 300 amp. welding transformer with high frequency unit is all that is needed to supply the power. Power return is by ground lead clamped to the work at any convenient location. A timer control automatically takes care of operating the accessory equipment.

Equipment is simple

Only one hose assembly connects the torch to the accessory equipment which can thus be placed out of the way to leave the entire work area free. The standard hose assembly is 25 ft. long. The hose is about an inch in diameter and contains conductors for power cable, cooling water, shielding gas, and trigger control. Electrode adjustment is easily made by push-button control located on the torch. All of these features make the spot welding torch easy and natural to use and as light and portable as an oxy-acetylene blowpipe.

The ease of use and quality of work done with HELIARC torch spot welding makes it an ideal production line tool. Contact any LINDE office for additional information about this new spot welding process.

The words "Linde" and "Heliarc" are registered trade-marks of The Linde Air Products Company.

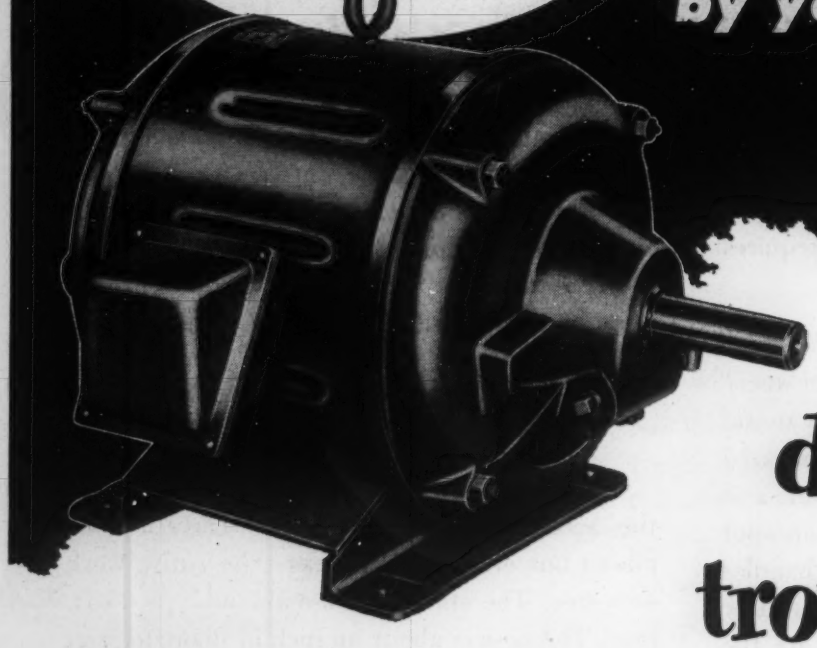
Linde Trade-Mark

THE LINDE AIR PRODUCTS COMPANY
Unit of Union Carbide and Carbon Corporation
30 E. 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities
In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

Wagner STEEL-FRAME Motors

Proved

by years of service!



quiet... dependable... trouble-free!

Since 1930, when Wagner started manufacturing steel-frame drip-proof motors, they have been *proved*—by years of hard usage in industry after industry.

Today this time-tested design is available in polyphase motors through 326 frame size. The motor frames are formed of heavy rolled steel, shaped to accurately center the stator core and to provide passages for adequate ventilation. An auxiliary fan draws in air through the openings in the front endplate, forces it through these passages and out through the endplate openings on the drive end. Heat is effectively carried off from all parts of the motor.

These motors are available with either sleeve or ball bearings. They are completely drip-proof when mounted in the normal horizontal position, and by rotating the endplates are still drip-proof in the sidewall or ceiling horizontal positions.

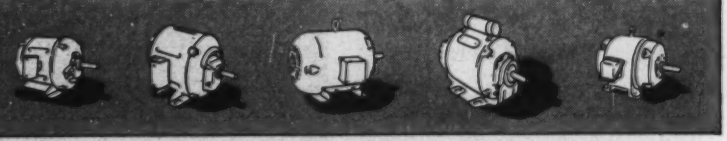
Bulletins give full information on the complete line of Wagner Motors. Twenty-nine branches, located in principal cities, are ready to assist you whenever you have a motor problem. In addition, almost 500 authorized motor repair shops provide speedy, nationwide service facilities.

Wagner Electric Corporation

6404 PLYMOUTH AVE., ST. LOUIS 14, MO., U. S. A.

Consult Wagner Engineers on all Electric Motor Problems

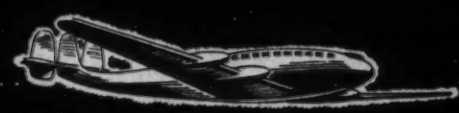
Wagner Electric Corporation EST. WE 1891



M49-2

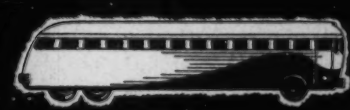
• ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE PRODUCTS •

Plane



Train

Bus



Truck
or
Car

All transportation GAINS
wherever
Superior Stainless

S[illegible] Strip Steel has [illegible] and rigidity that are [illegible] needs in transportation [illegible]. Superior St[illegible] has th[illegible] wear-proof, mar-[illegible] ness that keeps [illegible] Superior Stainl[illegible] clear-throug[illegible] at time and [illegible] grades, finishes, dim[illegible] all lengths do you require?

Superior Steel
CORPORATION
CARNEGIE, PENNSYLVANIA

Any V-BELT Changes Shape when it Bends

Prove this yourself!

That's Why the CONCAVE SIDE

(U. S. PATENT NO. 1813698)

Gives You 2 Big SAVINGS!

Bend *any* V-Belt and *f e e l* it change shape. The top, under tension, *narrows*. The body, under compression, *widens*. The sides of the belt bulge out.

Straight-Sided V-Belt

Straight-Sided V-Belt Bulges in Sheave-Groove.

The result, if the belt is built with *straight* sides, is a shape that does not fit the sheave groove — as shown in Figures 1 and 1-A, above.

Now, bend the V-Belt built with the precisely engineered Concave Side (U. S. Patent No. 1813698) — the Gates Vulco Rope.

Gates Vulco Rope With Concave Side.

No Side Bulge. Precise Fit in Sheave Groove.

You get the same shape change but *now* the new shape *exactly fits* the sheave groove as shown in Figures 2 and 2-A.

Results— (1) *Uniform* side-wall wear; *longer* life. (2) *Full* side-wall grip on the pulley; carries heavier loads and sudden load increases without slippage—a big increase in drive efficiency—saving belt wear a n d also saving power!

REG. U. S. PAT. OFF.

The Mark of SPECIALIZED Research

The Concave Side is MORE IMPORTANT NOW Than Ever Before

Because the *sides* of a V-Belt are what actually *drive* the pulley, it is clear that any increased load on the belt means a heavier load that must be transmitted to the pulley *directly* through the belt's side-walls.

Now that Gates *SPECIALIZED* Research has m a d e available to you SUPER Vulco Ropes—carrying fully 40% higher horsepower ratings—the life-prolonging Concave Side naturally delivers greater savings today than ever before.

48T2

GATES VULCO ROPE DRIVES
IN ALL INDUSTRIAL CENTERS

THE GATES RUBBER COMPANY
DENVER, U.S.A.
"The World's Largest Makers of V-Belts"

Portable Power . . .
PROTECTED POWER

with a LORD Vibration Control System

INET portable "Ground Power" units carry power to the job. They have an enviable reputation for their rugged dependability in a wide diversity of applications.

The vital and sensitive electronic control is protected from damaging vibration by a Lord Vibration Control System, engineered as an integral part of the unit. Through the protection thus provided stable voltage is assured, tube breakage is minimized, instrument life is prolonged, and maintenance cost of delicate parts greatly reduced.

INET thus gives further evidence of the growing recognition of the need for effective Vibration Control to improve performance and prolong life. Have you considered the potential improvement in your product, possible through Lord Vibration Control? Consult an experienced Lord engineer. There is no obligation.

See our bulletin in Sweet's 1949 File for Product Designers or write for Bulletin 900 today. It describes the complete line of Lord products and services.

LORD Vibration Control Systems

LORD MANUFACTURING COMPANY, ERIE, PA.

Canadian Representative: Railway & Power Engineering Corp. Ltd.

HERE'S WHY NEOPRENE PRODUCTS DO SO MANY JOBS SO WELL

They resist
SUNLIGHT AND WEATHERING—in a class by themselves in resistance to rubber's worst enemies.

They resist
OILS, SOLVENTS, MOST CHEMICALS—set the standard for oil resistance throughout industry.

They resist
ABRASION, CUTTING, CHIPPING—are tough and durable under severe service conditions.

They resist
AIR AND GAS DIFFUSION—have low permeability to gases—retain air longer.

They resist
LOW TEMPERATURE STIFFENING—special compounds retain flexibility at sub-zero exposure over long periods.

FREE! THE NEOPRENE NOTEBOOK—Interesting stories...new, unusual applications of neoprene. Write E. I. du Pont de Nemours & Co. (Inc.), Rubber Chemicals Division A-1, Wilmington 98, Delaware.

Better rubber products are made with Du Pont NEOPRENE

for example:

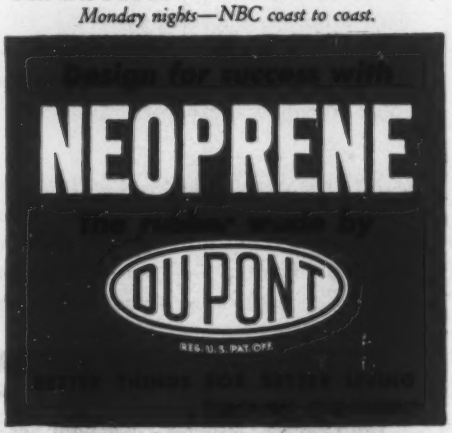
Neoprene packing rings in pipe coupling resist oils, gasoline and heat of welding

The Saftyweld* Coupling is designed to join oil pipe-line sections quickly and securely. It consists of a steel sleeve with internal grooves into which are fitted neoprene packing rings. To install, the coupling is slipped over the pipe sections to be joined, is clamped in place with set screws; then a special neoprene compound is forced behind the packing rings at the pressure connections. This seats the packing rings against the pipewalls. When this seal is formed, the line can be put into full pressure service at once. Welding can be done immediately or postponed until convenient.

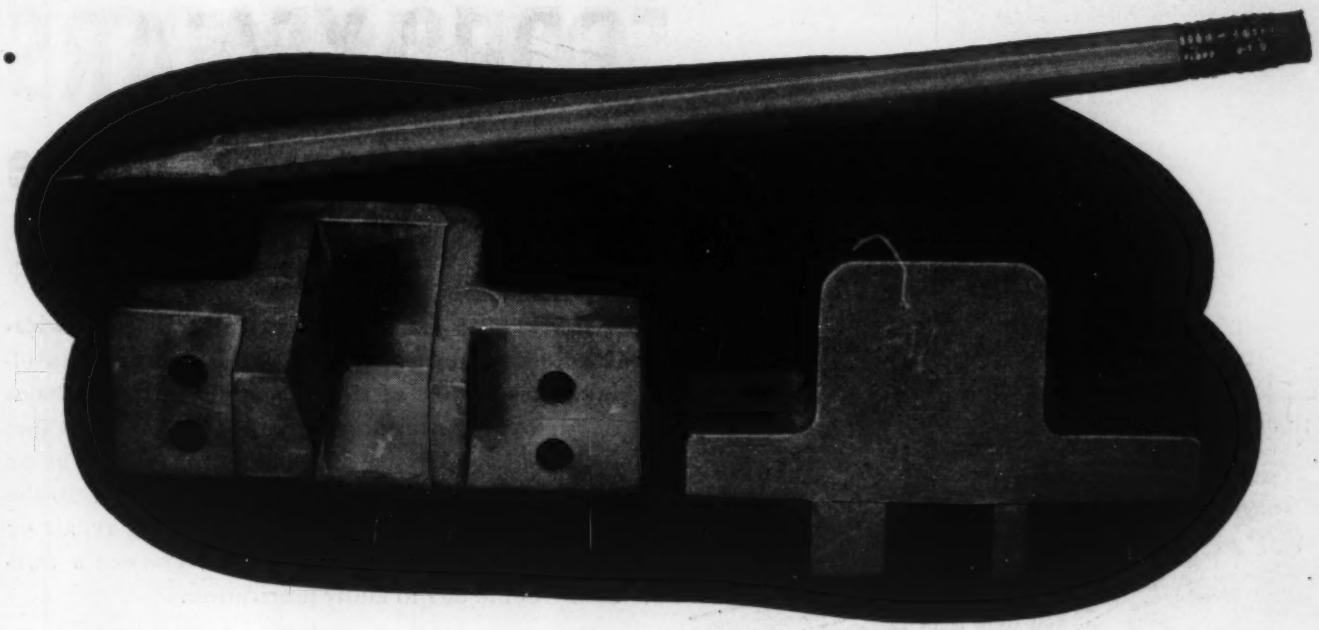
Neoprene was chosen for "Saftyweld" Couplings because it resists oils and gasoline . . . retains a high tensile and shearing strength . . . and resists heat caused by the welding operation.

Perhaps neoprene can help you design or improve *your* products. Write us for complete technical data. Du Pont does not make neoprene products, but we'll be glad to contact your supplier or help you find an adequate source. E. I. du Pont de Nemours & Co. (Inc.), Rubber Chemicals Division A-1, Wilmington 98, Delaware.

Tune in to Du Pont "CAVALCADE OF AMERICA," Monday nights—NBC coast to coast.



**Saftyweld—Trade mark of The Standard Oil Company (Ohio). Saftyweld Couplings manufactured and distributed by Clark Goodman Supply Co., Cleveland, Ohio.*



Design problem –solved in one operation

There is a story behind this picture worth several thousand dollars to one manufacturer. It may be worth a tidy sum to you, too.

Looking at the picture you see two life-size views of a Monel part used in quantity by this machinery manufacturer.

Just make a quick estimate as to what you would expect to pay for it. Consider the cost of the forging dies... broaching the slot... silver-soldering the back plate to close the end... drilling four bolt holes... and facing the back flange to fit the curved contour of a cylinder.

Something around $3.25, wouldn't you say?

Actually, this manufacturer is getting these parts exactly as you see them for just about a third less than you estimate.

How? By precision casting. One operation, one piece—and there you have the finished part all ready to bolt on the machine.

That is just one example of the variety of different parts now being produced in INCO's new Precision Casting Plant. The beauty of precision casting is the way its versatility opens up new possibilities for quantity-producing metal parts in designs too intricate to fabricate economically by conventional methods or downright impractical to produce by any other method.

INCO Nickel Alloys

Monel • "R"* Monel • "K"* Monel • "KR"* Monel • "S"* Monel Nickel • "L"* Nickel • "Z"* Nickel • Inconel** *Reg. U.S. Pat. Off.

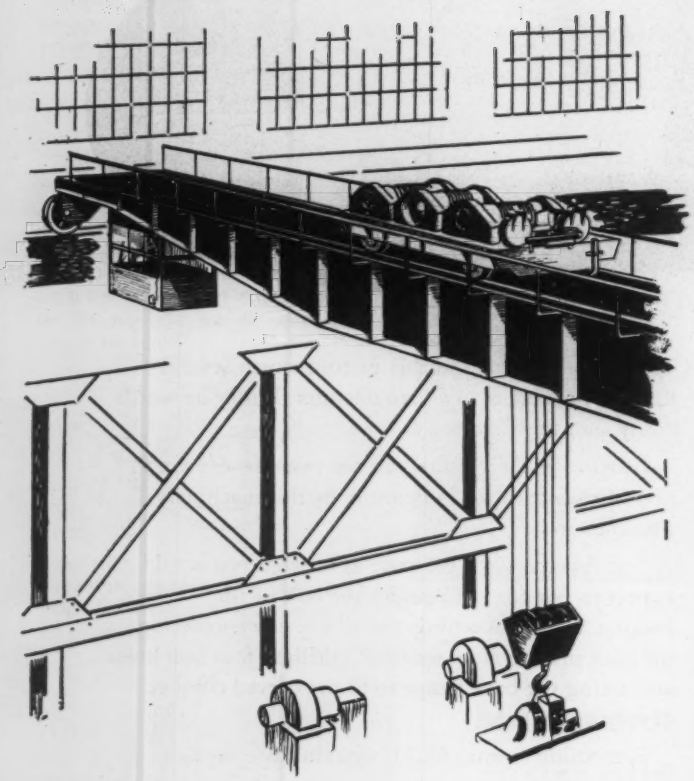
"Task Metals" for Industry

IF YOU HAVE A PROBLEM *with a part whose cost seems too high... or a part where a precision casting might eliminate a number of operations (as with this latch-keeper)... or a part whose design cannot be practically worked out via other methods... send us a sample or blueprint, along with the approximate quantity needed. Within a few days you'll receive our frank answer telling you whether or not precision casting offers a better solution. Address your letter to our Bill Calnan.*

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N.Y.

EMBLEM OF SERVICE
INCO
TRADE MARK

FOR 18 YEARS
never a bearing failure with Farval



FARVAL—*Studies in Centralized Lubrication* No. 106

EIGHTEEN years ago, Farval Centralized Lubrication was installed on a 10-ton overhead traveling crane in one of the steel mills in the Chicago district. A recent report on this early job states that the Farval systems are still in service, as good as on the day they were installed, and that since 1930 the crane has never been down for a bearing repair or replacement. In short, there has never been a minute's trouble due to faulty lubrication.

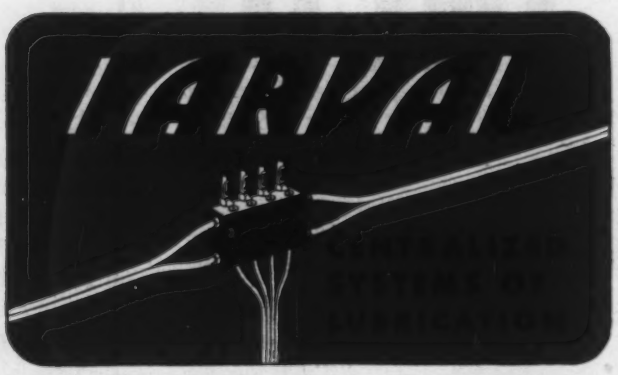
Two manually-operated Farval systems—one on the bridge and one on the trolley—serve 56 points of lubrication including the wheel bearings. In less than five minutes, every eight hours, the operator lubricates every bearing on the crane from two conveniently located hand pumps. No need to climb all over the crane and never a bearing is skipped. Grease consumption is greatly reduced because there is no waste, and drippage is practically eliminated.

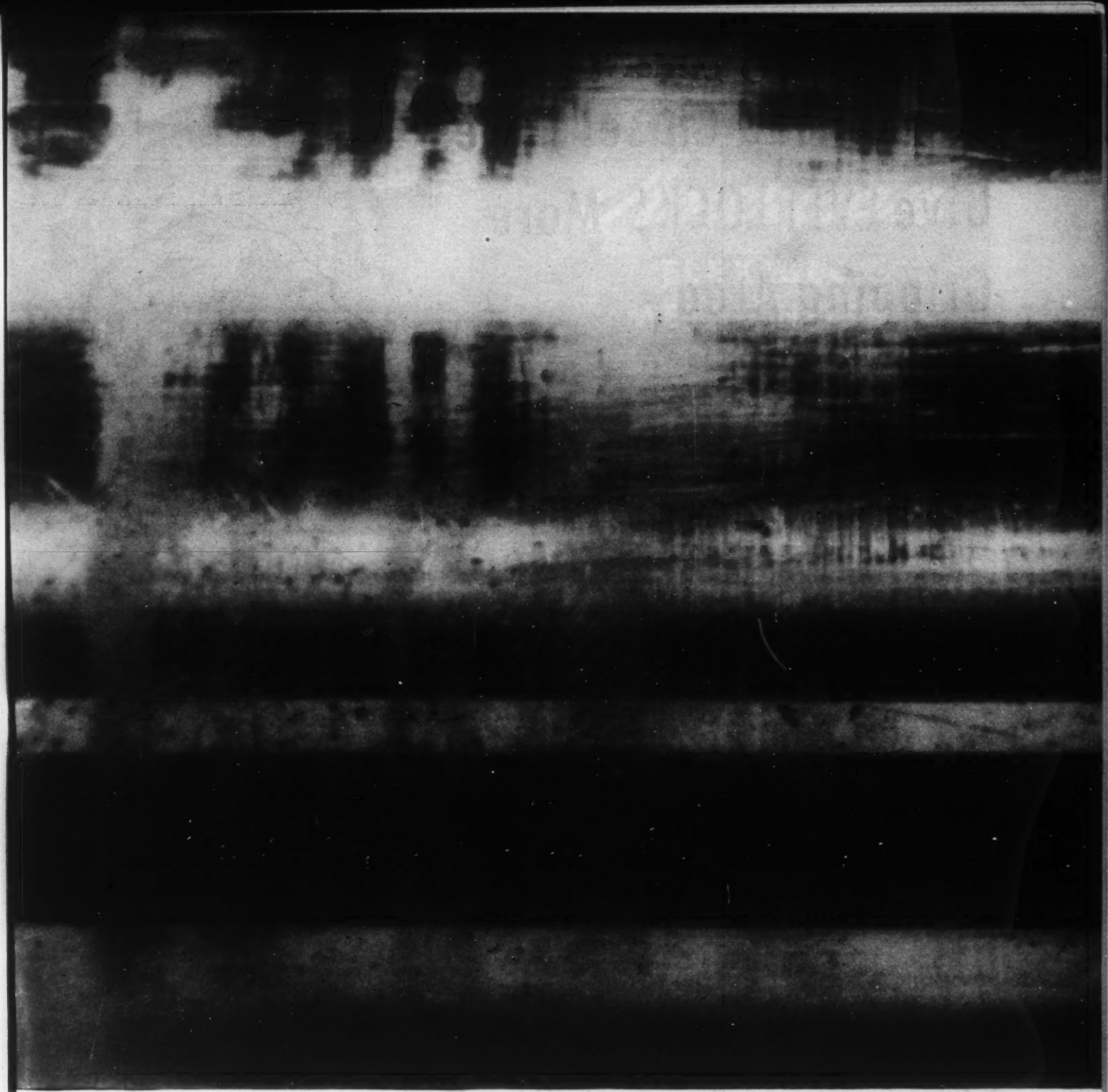
More than 2000 Farval systems have been installed on cranes. Many of them are roller bearing cranes, where clean grease is essential and over-lubrication should be avoided.

Farval delivers oil or grease under pressure to a group of bearings from one central station, in exact quantities, as often as desired. It does its work while the equipment is in operation. Farval—the Dualine System with the Positive Piston Displacement Valve—that has but 2 Moving Parts—is Fully Adjustable—and with a Tell-tale indicator at each bearing to show the job is done.

Write for Bulletin 25 for a full description of Farval. The Farval Corporation, 3265 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.



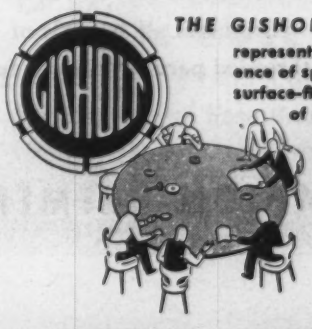


Close-up of *DANGER!*

The main bearing of this small crankshaft was originally finished by a mechanical sanding machine. Then it was partially Superfinished—just enough to reveal the lack of adequate bearing capacity. Light abraded areas are the only true geometrical surface. Dark areas are low spots which carry no bearing load. The area contact of the Superfinishing stone brings out deficiencies in production which were never intended by the designing engineer.

For more information on Superfinishing, write on your company letterhead for the new textbook, "Wear and Surface Finish."

GISHOLT MACHINE COMPANY
Madison 10, Wisconsin



THE GISHOLT ROUND TABLE
represents the collective experience of specialists in machining, surface-finishing and balancing of round and partly round parts. Your problems are welcomed here.

TURRET LATHES • AUTOMATIC LATHES • SUPERFINISHERS • BALANCERS • SPECIAL MACHINES

Many Wide Chisel Edges Give EVERLOCKS More Gripping Area

This patented EverLOCK feature gives the extra staying power needed to protect your assemblies under all conditions. Note the photographic evidence of extra gripping area each of EverLOCK's many wide chisel edges apply to both work and nut. Full use of this added area of resistance against expansion, contraction and strain is assured by powerful spring tension which drives and holds each of the many wide chisel edges into positive locking action.

Application is fast and easy . . . saves assembly time and labor . . . eliminates all hazards of stretched bolts and distortion of threaded parts. Write for full particulars.

Ever LOCK WASHERS

THE WASHER THAT HAS THE EDGE

THOMPSON-BREMER & CO., 1640 W. HUBBARD ST., CHICAGO 22, ILL.

This Thermo-Blo air cooling unit attaches to Linotype machines for the cooling of hot type molds. Manufactured by Mergenthaler Linotype Company, Brooklyn, N.Y.

SIMPLIFIES INSTALLATION

for this cooler of hot Linotype molds

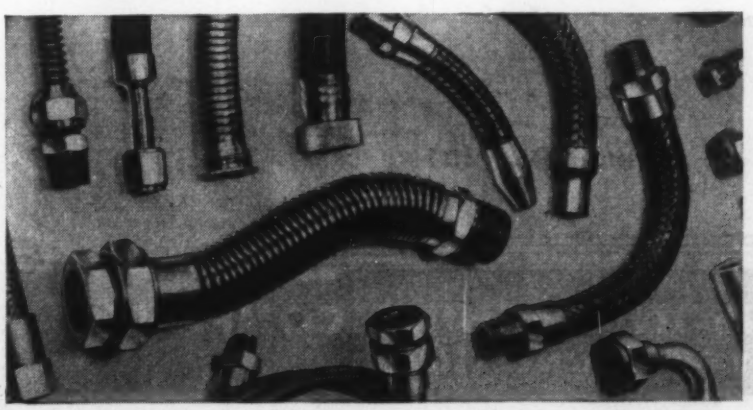
The requirements indicated flexible metal hose: to carry up to 200 cubic feet of air a minute to hot Linotype molds . . . must be rugged, foolproof, quick to install . . . flexibility needed to counteract vibration, simplify alignment.

And American Flexible Metal Hose it was. For this particular application—the Mergenthaler Thermo-Blo air cooling unit for Linotype machines—American selected Type VAC Interlocked Flexible Steel Hose with asbestos-packed joints. The complete assembly is supplied with end fittings attached—designed by American from fitting to fitting at no extra cost.

SPECIAL DESIGN . . . NO CHARGE

Bring your connector problems to American. It doesn't matter whether they involve carrying water, steam, oil, other liquids, semi-solids, gases —or problems of misalignment, vibration, piping in cramped spaces, connecting moving parts. (You may even require a flexible connector of a special, rectangular shape.) An American flexible connector may be your answer. Remember, there's no charge for special design, and your connector can be furnished as a complete, ready to install assembly. Write for literature.

48298



ANACONDA
from mine to consumer

American
METAL HOSE

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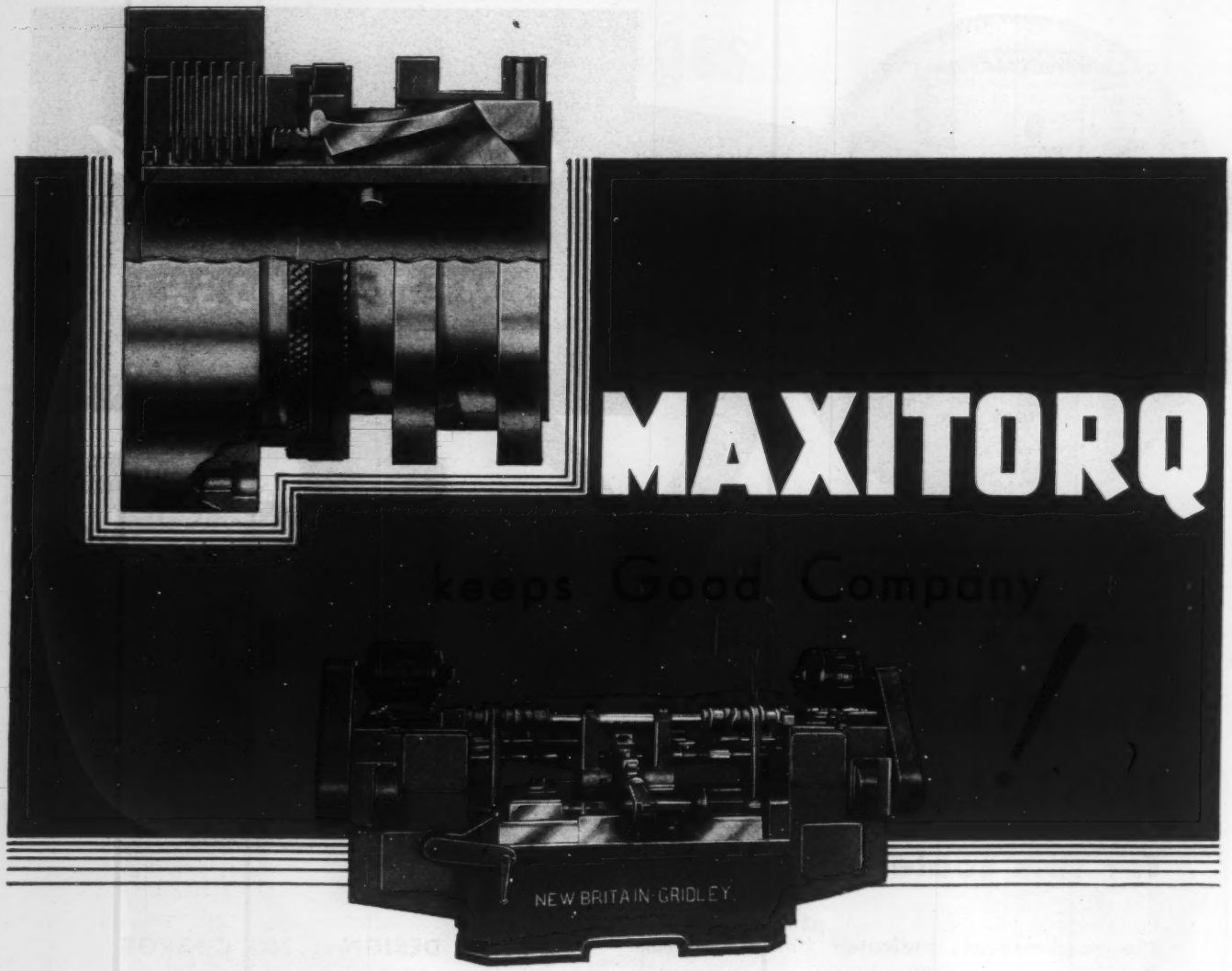
Subsidiary of Anaconda Copper Mining Company
Distributed in Canada by:
THE CANADIAN-FAIRBANKS MORSE COMPANY, LIMITED



THE MAXITORQ Floating Disc Clutch was designed to solve certain power transmission problems, especially those formerly encountered in automatic machine tool operation. As evidence that MAXITORQ design has proven successful we show the new Double End Tool Rotating Chucking Machine, manufactured by New Britain-Gridley Machine Division.

Normally two single clutches are used in this model . . . one to control feed motions, the other for control of the rapid transverse. When threading is done, at either or both ends of the machine, one double clutch serves each spindle.

May we suggest that Designers and Manufacturers of machine tools, and other machinery, ask for our detailed bulletin. It contains information you need . . . about the clutch you can use . . . profitably.

Send for Catalog No. MD1

ICJ48

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

HASTELLOY TRADE-MARK *Alloy Wire*

FOR METAL-SPRAYING, WELDING, and FABRICATED WIRE PRODUCTS

HASTELLOY nickel-base alloys, in the form of drawn wire, are available for the fabrication of corrosion-resistant screen, cloth, and baskets. The wire is also excellent for metal-spraying and for many types of automatic welding and hard-facing.

HASTELLOY alloys have a tensile strength comparable to that of the high-strength alloy steels, and possess unusual strength even at elevated temperatures. These alloys are specially designed to withstand the most severe conditions of chemical corrosion. Nickel-molybdenum alloy B is particularly resistant to hydrochloric and sulphuric acids, many organic acids, and all alkalies. Alloy C, a nickel-molybdenum-chromium-tungsten-iron composition, has excellent resistance to strong oxidizing agents, such as ferric chloride and wet chlorine, and is outstanding in its resistance to brine and salt spray.

In addition to HASTELLOY alloy wire, you can also obtain wire made of MULTIMET alloy—a cobalt-chromium-nickel composition developed for service at elevated temperatures.

Cut and straightened lengths or coils, in diameters down to 0.060 in., can be obtained directly from Haynes Stellite Company, Kokomo, Indiana. Wire in diameters less than 0.060 in. down to 0.002 in. is available from an associate company, Kemet Laboratories Company, Inc., Madison Avenue and West 117th Street, Cleveland 1, Ohio. For more complete information, write for a copy of the booklet, "HASTELLOY High-Strength, Nickel-Base, Corrosion-Resistant Alloys."

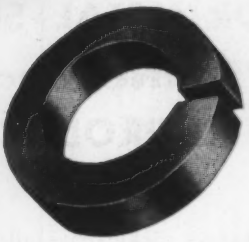
HAYNES TRADE-MARK *Alloys*

Haynes Stellite Company
Unit of Union Carbide and Carbon Corporation
UCC
General Offices and Works, Kokomo, Indiana
Sales Offices
Chicago—Cleveland—Detroit—Houston
Los Angeles—New York—San Francisco—Tulsa

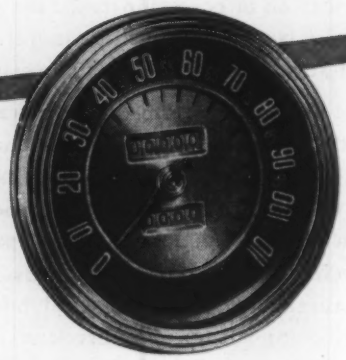
The terms "Haynes," "Hastelloy," "Multimet," and "Unionmelt" are trade-marks of Units of Union Carbide and Carbon Corporation.

WHEN THIS NEW INDIANA PERMANENT MAGNET

REPLACED THIS OLD ONE



A BETTER SPEEDOMETER WAS BORN



New King-Seeley speedometer

★

Indiana—world's largest exclusive producer of permanent magnets—is the *only* manufacturer furnishing all commercial grades of permanent magnet alloys. Most commonly used are:

CAST:
Alnico I, II, III, IV, V, VI, and XII; Indalloy; Cunico; Cobalt.

SINTERED:
Alnico II, IV, V; Indalloy; Vectolite.

DUCTILE:
Cunico; Cunife I and II; Silmanal.

FORMED:
Chrome; Cobalt; Tungsten.

Ask for free Book No. 4-H1—our new permanent magnet engineering manual. A note on your company letterhead will bring a copy to your desk.

40 YEARS OF BETTER PERMANENT MAGNETS

★

Indiana's experience brings Better Designs, Lower Costs

Recently our engineers, working with those of King-Seeley Corp., helped design an entirely new permanent magnet for a greatly improved speedometer. This *Indiana* magnet, made of Cunife, weighs *one third less* than the previous magnet, yet has *30% more energy.* It reduces bearing load by 50%, and is 750% more stable—is *far* more resistant to shock, temperature change, stray magnetic fields. And it *costs less.*

WE MAY HAVE *YOUR* ANSWER, TOO

For four decades, the pace-setting design techniques at *Indiana* have made possible new and better permanent magnets. This "packaged energy" improves performance, adds new functions, *saves money* in countless different products . . . as mechanical force in holding and separating devices . . . for changing electrical energy to mechanical motion and vice versa . . . for changing the apparent characteristics of materials. *Indiana* offers you the experience and know-how of more than 30,000 different applications. Let's get our engineers together on *your* problem. Write *today.*

THE INDIANA STEEL PRODUCTS COMPANY

PRODUCERS OF "PACKAGED ENERGY"
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SPECIALISTS IN PERMANENT MAGNETS SINCE 1908
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There's no "hand-power" in modern heating

. . . thanks to the Appliance Industry

Americans have *many* reasons to be grateful to the appliance industry. For much of the ease, the convenience and the healthfulness of modern American life is due to modern American appliances. Delco Products is proud of its part in this great industry. Many of the first models of famous appliances were powered by especially developed Delco Motors. And as these products have been consistently improved, so Delco Motors have been made ever more efficient and dependable. Built in sizes from 1/8 to 50 h.p., Delco Motors are quiet, compact and designed to fit the requirements of the particular application. Delco Products Division, General Motors Corporation, Dayton, Ohio.

DELCO PRODUCTS DAYTON, OHIO

Delco Motors

ica's Leading Appliances

Added value for your design . . .
Piping from the CRANE line

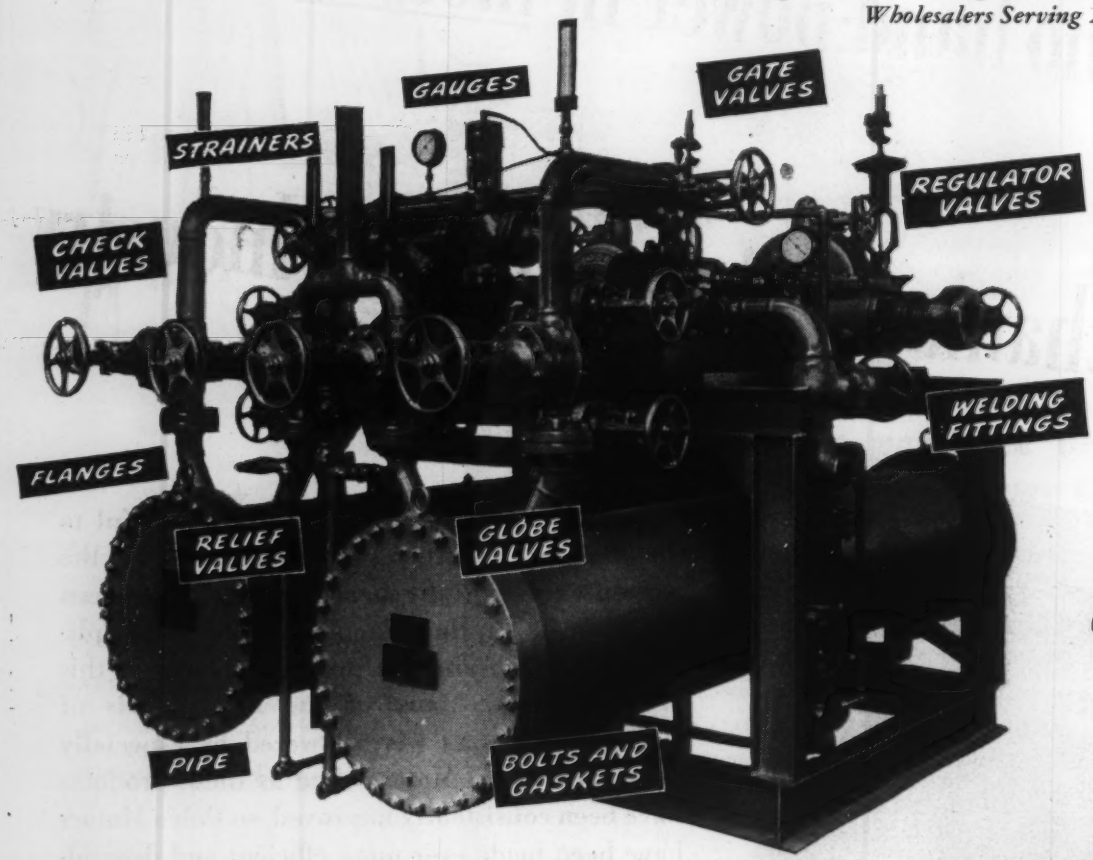
ONE
SOURCE OF SUPPLY
RESPONSIBILITY
STANDARD OF QUALITY

When the piping on your design is Crane, buyers recognize it as a sign of added value. Why? Because they know from experience that Crane Quality stands for **High Quality**—unsurpassed today as for more than 90 years.

This Fuel Oil Pump and Heater Unit, for example, bears the stamp of added value—Crane—on all valves, fittings, accessories and pipe. Here, piping equipment is used to control the flow of steam and heated fuel oil. But regardless of fluids to be handled, the complete Crane line has the piping you need . . . conveniently listed in one catalog.

Because Crane supplies everything, specifying from this **Single Source of Supply** simplifies all piping procedures. It facilitates buying and storekeeping, for instance. And putting **Undivided Responsibility** for materials on Crane results in smoother assembly operations; assures better control of factory schedules.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Illinois. *Branches and Wholesalers Serving All Industrial Areas.*



Fuel Oil Pumping and Heating Unit by A. M. Lockett & Co., Ltd., New Orleans. Completely equipped by Crane.

IN STEEL VALVES *for oil or oil vapor service as on fuel pumps, Crane supplies gates, globes, angles and checks, cast and forged, in pressure classes for all applications. Shown here, Crane No. 143½X Cast Steel Globe Valve with welding ends for maximum temperatures of 500 deg. F. Exelloy to Exelloy seating. Sizes: 2 in. and larger. See your Crane Catalog, p. 324.*

EVERYTHING FROM . . .

VALVES · FITTINGS
PIPE · PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM

NATIONAL OIL SEAL LOGBOOK

USE OF OIL SEALS IN HIGH SPEED MECHANISMS WHEN EXTREME OPERATING CONDITIONS EXIST

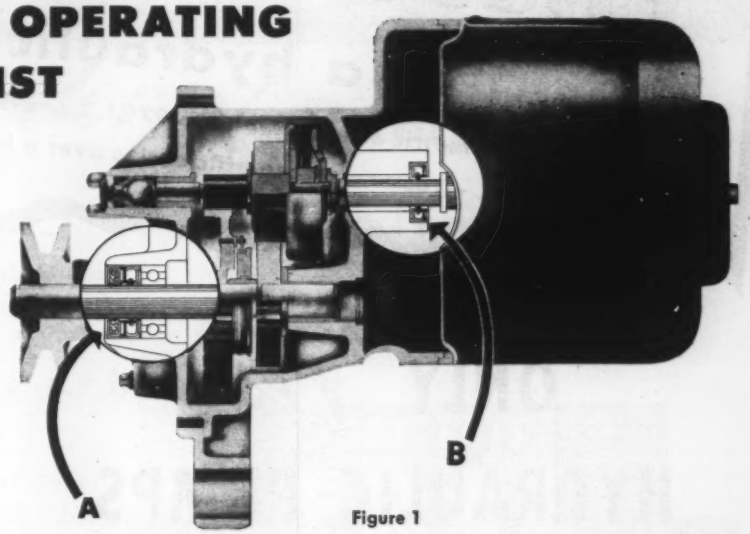


Figure 1

Specifying the right oil seal is particularly important when fine-tolerance machines must operate under unusually adverse conditions.

Frequently, precision assemblies such as gear head motors operate for long periods of time in heavy dust and dirt conditions. Speeds exceed 2,000 RPM, lubricant pressure heads must be contained, torque must be held low, and space limitations in the housing area are often critical.

EXCLUDING DUST, DIRT

Typical of such sealing problems is the gear head motor in Figure 1. Here seals are required at A and B. Seal A retains gear box lubricant and excludes abrasives. Under average dust and dirt conditions, a single-wipe, spring-loaded synthetic rubber seal (Figure 2) is effective. However, when abrasive hazards are great a double-wipe seal with an auxiliary sealing member of leather, felt or rubber (Figure 3) is indicated. When speed is low and dirt conditions are severe, the auxiliary should be rubber. At medium speeds with heavy abrasive conditions, a leather auxiliary is often used. At high speeds with lighter abrasive conditions, a felt auxiliary is effective.

SEALING FLUID HEADS

At B in Figure 1, the application requires an absolute seal between motor and gear box. Spring-loaded, synthetic-rubber, single-wipe seals are effective with moderate or heavy pressure heads. For very heavy pressure heads, special pressure-type synthetic rubber single-wipe seals are used when speeds are not high. For extreme pressures and speeds, a special "face-type" seal is often required. On the other hand, *springless* seals (Figure 4) can often be used for very light pressure heads, when shaft size is small. These seals have proven ideal in many cases where water or industrial fluids are to be sealed, and speeds are relatively low.

SPECIAL SEALS

However, when abrasive, speed, space or other extremes exist, the sealing problem is often solved only through the design of a special seal. National Oil Seal Engineers have helped design and build many such seals. They have also assisted designers in the application of National Oil Seals from stock. Before specifying seals, consult with the nearest National Engineer, or write direct to our Redwood City, California, home office. All data is held confidential.

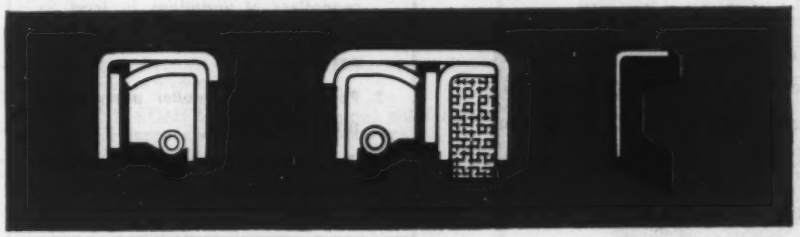


Figure 2 Figure 3 Figure 4

NATIONAL
OIL AND FLUID SEALS

NATIONAL MOTOR BEARING CO., INC.

General Offices: Redwood City, California
Plants: Redwood City and Los Angeles, California; Van Wert, Ohio

CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS

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NEW YORK CITY: 122 East 42nd Street, Lexington 2-8260. **PHILADELPHIA:** 401 North Broad Street, Bell-Walnut 2-6997.
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PRESSURE LOADING

in a hydraulic pump

...provides volumetric efficiencies up to 97%!...provides torque efficiencies up to 90%!

...assures these efficiencies over a longer service life!

ONLY *Pesco* HYDRAULIC PUMPS GIVE YOU PRESSURE LOADING

This booklet explains PRESSURE LOADING . . . write for your copy today.

Pressure Loading is a Pesco patented principle of hydraulic pump design which utilizes pressure from the discharge of the pump to maintain a minimum end clearance between gear and bearing faces. This automatically compensates for wear.

Pesco hydraulic pumps with *Pressure Loading* will not "freeze" under normal load conditions. They have an unusually long service life. They require minimum maintenance. Do not require micrometer fits. They guarantee highest possible efficiencies under all operating conditions.

Only Pesco hydraulic pumps have *Pressure Loading*. If the design of your product calls for the use of hydraulic pumps . . . or other hydraulic equipment . . . it will pay you to send for your copy of the free booklet, "Pressure Loading by Pesco".

OTHER ADVANTAGES OF PESCO PRESSURE LOADED HYDRAULIC PUMPS

1. Provides uniform rate of fluid flow regardless of variations in load, in viscosity of hydraulic fluid, or in temperature.
2. Permits use of smaller pump for a given installation.
3. Accomplishes more work per unit of energy expended.

Pesco PRODUCTS DIVISION
BORG-WARNER CORPORATION
11610 Euclid Ave. - Cleveland 6, Ohio

MANUFACTURERS OF BW SUPERCHARGERS

If You Need A Low Pressure Low Cost Pumping Unit . . .

Complete with:

- ✓ **Pump**
- ✓ **Relief Valve**
- ✓ **Strainer**

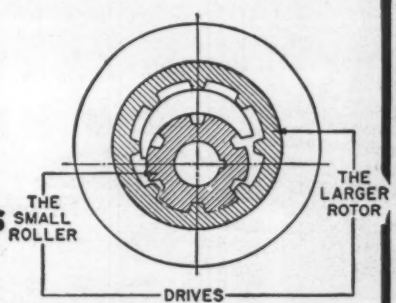
Yes, here's the combination pump you've been looking for. Time-tested, efficient and quiet, it's complete with releif valve and strainer and, like all Sundstrand Pumps, it embodies the ROTA-ROLL principle and pumping members. So, if you need or use pumps of this capacity, be sure to investigate this low cost complete pumping unit.

Available in 5 Sizes: From 6 G.P.H. To 35 G.P.H.

This pump has an adjustable relief valve for settings up to 300 PSI. The five sizes range from 6 G.P.H. to 35 G.P.H. These figures are based on a motor speed of 1725 RPM and 100 PSI.

GET THIS **FREE** BOOK

Rota-Roll Principle Offers 6 Advantages



1. ROTA-ROLL PRINCIPLE of pumping members promotes quiet operation, longer life because (see above) smaller roller is keyed to shaft and drives outer member at a speed 25% lower than motor speed.
2. QUIET OPERATION because ROTA-ROLL pumping members and efficient inlet port design reduces cavitation at the inlet port.
3. SMOOTH UNIFORM FLOW AT ALL PRESSURES because rotating roller and rotor are self-emptying, eliminating turbulence, and other interference with smooth uniform flow of oil.
4. SMALL AND COMPACT (see illustration) will lend itself to and improve your product appearance.
5. HIGH OVERALL EFFICIENCY at maximum continuous duty pressure.
6. *LOW COST—Manufacturers list price f.o.b. Rockford, Illinois, for 35 G.P.H. unit $16.90. Prices for smaller capacity units slightly less.

SUNDSTRAND MACHINE TOOL CO. · ROCKFORD, ILLINOIS, U.S.A. ·

SUNDSTRAND HYDRAULIC DIVISION

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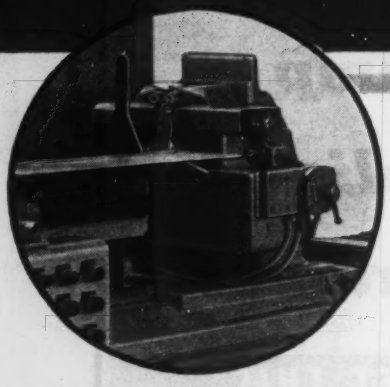
FUEL UNITS • HYDRAULIC PUMPS • TRANSMISSIONS • FLUID MOTORS • VALVES and CONTROLS

Grinds both SPLINES and GEARS

Handles Work up to 48" Long . . .



For grinding involute gears and splines this machine can be equipped with the Geargrind Involute Trimmer. This has the capacity to true wheel from 32 to 4 diametral pitch.

● On this combination machine the work reciprocates past the grinding wheel, which automatically feeds down each time the work reverses. Grinding continues on one tooth space until a predetermined size is reached, after which the dresser moves into position for trueing the grinding wheel. All operations are automatic.

After the wheel is dressed the operator finish grinds in the conventional manner, indexing automatically from tooth to tooth.

Grinding is 3 to 4 times faster than by any previous machine of comparable capacity, due to 1), reduction of total number of indices required, 2), less carriage travel due to short roughing stroke and 3), cycling control which prevents a slowing of the machine cycle. This also permits one man to operate more than one machine.

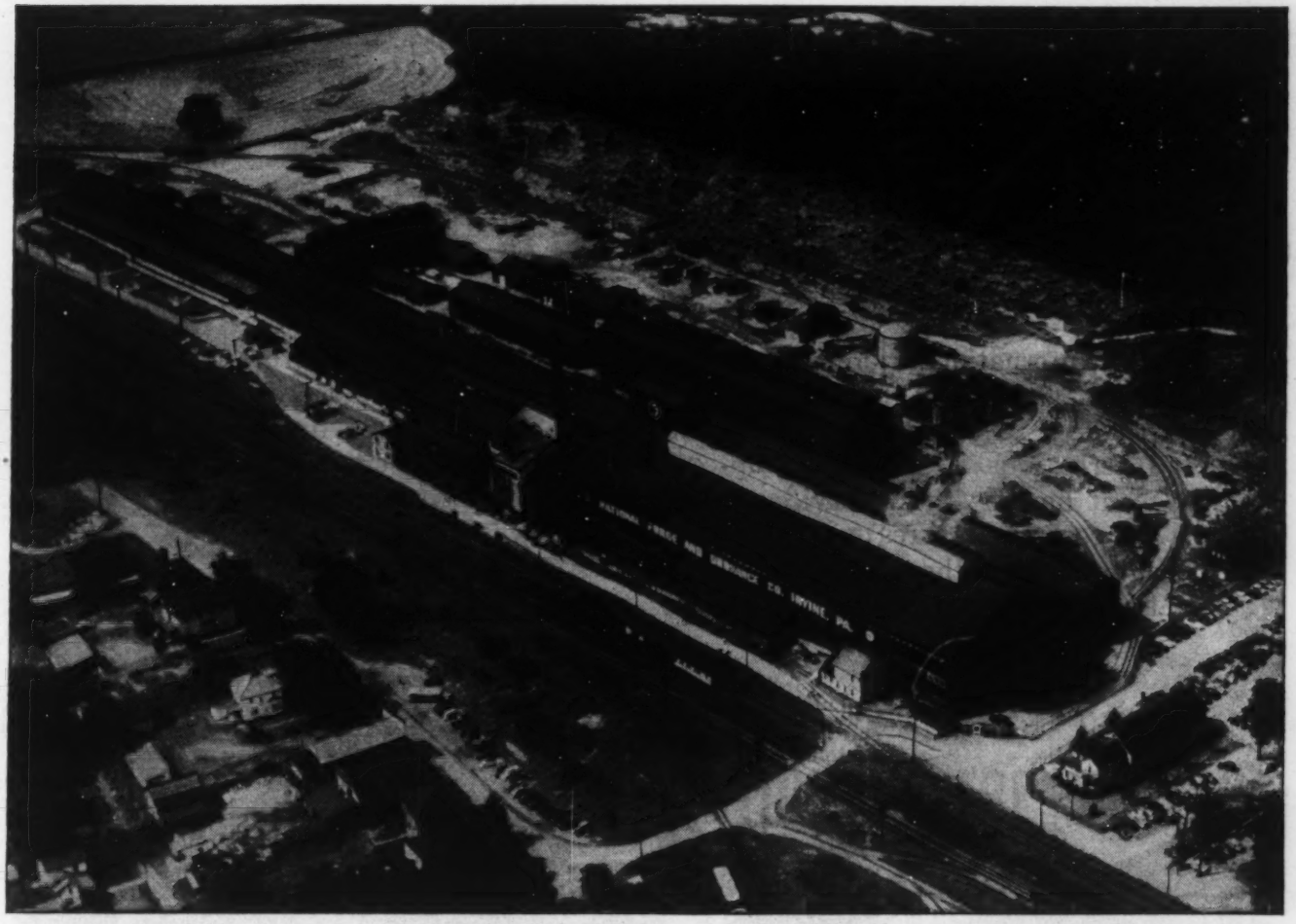
CAPACITY—SG-10x48A

Between Centers	Up to 48"
Spline OD	1" to 6"
Max. swing	12½"
Teeth	4 to 120
Face width	Up to 34"

Features—

- Double column support for grinding wheel head.
- Automatic, adjustable grinding wheel feed.
- Automatic wheel feed for trueing.
- Automatically cushioned trueing position.
- Automatic lubrication of ways.
- Axial grinding wheel spindle adjustment.
- Work table speeds up to 70 ft. per minute.
- Control panel, with counters to adjust grinding cycle, interlocking safety features, very accessible mountings of push buttons and other controls.
- Long base eliminates work table overhang. New way guards.
- Simplified stroke adjustment.
- Adjustable work arbor supports facilitate loading.
- Recessed dogs and stops, for operator's safety.

The GEAR GRINDING MACHINE COMPANY
DETROIT 11, MICH. U.S.A.



THIS IS THE BACKGROUND FOR BETTER FORGINGS IN 1949

The great scarcity in today's market of many raw materials and products, makes it most essential that everything be made of the best. We should not take chances by using inferior materials. This speaks for steel forgings particularly, because one of the critically scarce materials today is steel. We must conserve it, and one way to do that is to use forgings which will stand up and give continued service under the stress and strain of constant daily use.

In the plant pictured above the National Forge and Ordnance Company makes better forgings. Backed by years of experience, with equipment that is up to date in every respect, a skilled personnel turns out a product which has taken a well deserved place in the productive activity of this country.

The product is thoroughly controlled from start to finish. The steel used is made in Basic Electric Melting Furnaces located under the long ventilating louvre at the right of the picture. From that point it is forged, heat treated, and machined as it passes through the shop toward the left.

A better product can only be produced when it is made by men who possess the proper know-how and its production is supervised to assure that it receives every deserved attention. This is true of any product, and it is especially true of a steel forging.

The importance of the steel forgings you use, therefore, makes it advisable that you know, in detail, how well National Forge can serve you in the year ahead. The better your forgings, the better your product.

NATIONAL FORGE & ORDNANCE COMPANY, IRVINE, WARREN COUNTY, PA.

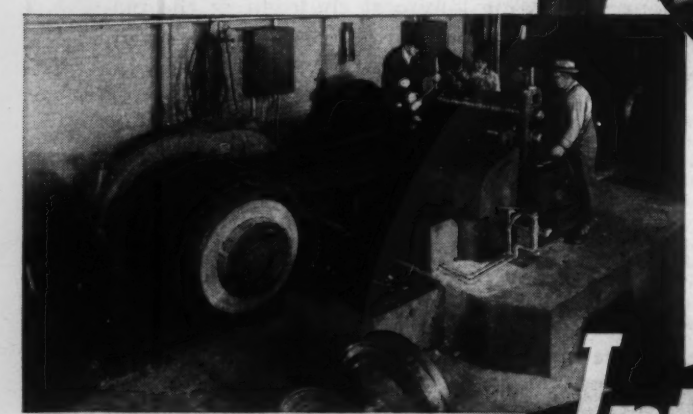
If You Use SHEET STEEL...

Let International quote on decoiling, flattening, cutting, and pickling. Also on coil-slitting. International's mill-type equipment handles these services at low cost, and assures dependable supplies even though mill facilities are crowded.

Hundreds of manufacturers look to International for steel service to assure a steady flow of incoming materials. Perhaps similar service can be arranged for you ... it will pay to inquire.

Coils up to 9 gauge (.150) can be handled by International's Flying Shear

Sheets from the Flying Shear are smooth, uniform, accurate to size



One of International's three coil-slitters that handle coils up to 60 inches wide

STEEL I SERVICE
INTERNATIONAL

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ROLLING MILL PRODUCTS CORPORATION

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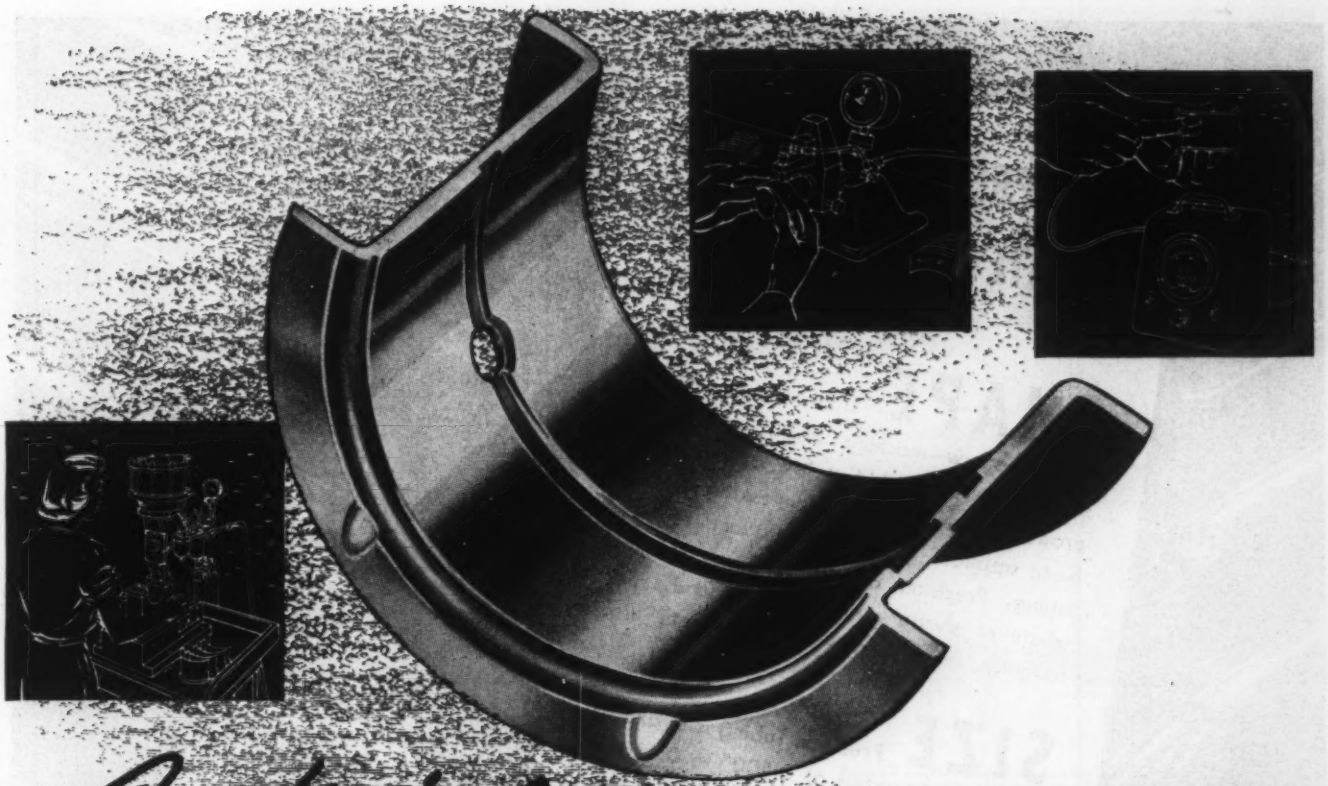


Combining PRODUCTION IN THE MILLIONS WITH QUALITY IN THE INDIVIDUAL BEARING

To assure top quality in mass production of sleeve bearings, at low cost, our Quality Control and Production Methods organization conducts as many as 108 separate tests for material quality and physical accuracy of the individual bearing. Specialists for almost 50 years, our six-plant organization is tailored to the peculiar needs of sleeve bearing production—from original research to field tests of the finished product. Our engineering department will gladly consult with you on your problems.

28 PRECISE MACHINE OPERATIONS

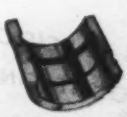
84 MEASUREMENT CHECKS

24 ADDITIONAL TESTS

are conducted on a strip-type, copper-lead lined, steel-backed flanged bearing.

HIGH SPEED, high temperature, automotive type bearings available in many combinations.

SPEED & LOAD bearings for pumps, compressors, industrial electric motors and similar uses.



HEAVY LOAD for big Diesels, power plants, etc.—bearings up to 27½" O.D., steel and bronze back.

BRONZE PARTS in many shapes, sizes; thrust washers, bushings; for many types of applications.

Power goes to work smoothly through

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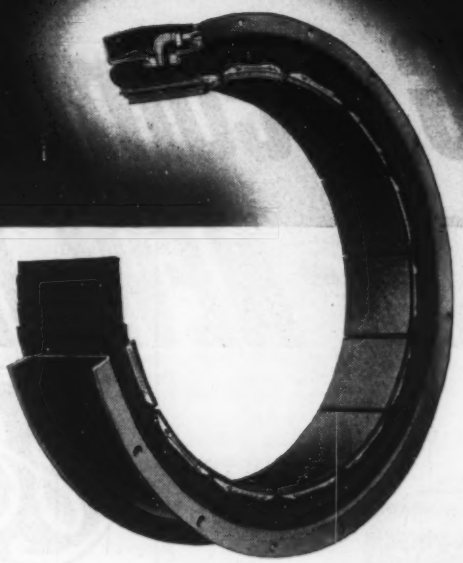
FEDERAL-MOGUL CORPORATION — 11045 SHOEMAKER, DETROIT 13, MICH.

FEDERAL Mogul — Silent SLEEVE BEARINGS

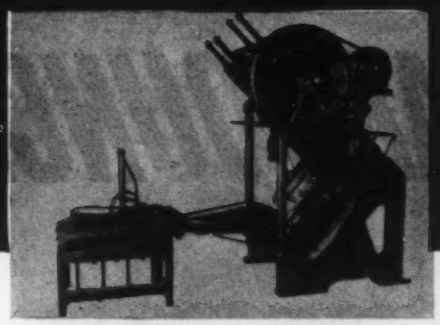
FOR PRECISION TUBING
WHATEVER THE . . .
SHAPE Instruments, pens, pencils, screw machine stock, and metal shielded wire are but a few of the many products to which small seamless tubing has been applied. When your products require tubing, Precision accurately forms it into whatever shape you specify—round, rectangular, oval—ready for immediate use.
SIZE Precision Tubing is available in outside diameters of 0.500" to 0.010"—wall thicknesses of 0.035" to 0.0015". Through continuous hydrogen atmosphere annealing furnaces and tungsten carbide tooling dimensions you specify within this range are held to extremely close tolerances.
ALLOY Whether it's an aluminum alloy used to acquire a finish suitable for color anodizing, an alloy for Bourdon gauges, nickel, monel, or any other non-ferrous alloy, Precision research subjects non-ferrous metals to rigid tests. These assure reliable operation even under extreme conditions. Controlled production cycles make possible a correct temper, a clean smooth finish, and the precise uniformity so essential to long life.
WHEN PRECISION COUNTS . . .
COUNT ON PRECISION
PRECISION TUBE CO.
SPECIALISTS IN ACCURATELY DRAWN TUBING AND METAL SHIELDED WIRE
Factory: 3824-26-28 TERRACE STREET · PHILADELPHIA 28, PA.
BRANCHES IN ALL PRINCIPAL CITIES

ONLY ONE MOVING PART

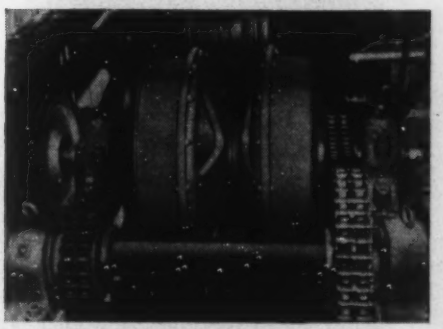
in this Fawick Clutch



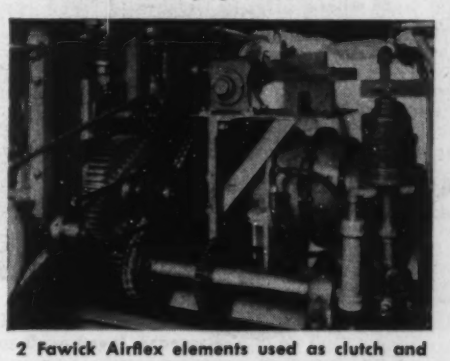
Fawick Airflex Clutch Type CB



Fawick Airflex element assembly, with 4 Fawick Quick Release Valves, on Callahan Can Machine Co. die crown cap blanking press.



Special Veneer Lathe equipped with 2 Fawick Airflex Speed Changing Clutches.



2 Fawick Airflex elements used as clutch and brake on "One Revolution Knife" by Roofing Machinery Manufacturing Co.

The rubber-and-fabric pneumatic tube faced with friction shoe assemblies is the only moving part in this Fawick Clutch. This part naturally stays in perfect adjustment at all times—automatically compensating for wear of the friction shoes.

Job-tested, Fawick Clutches meet the toughest operating conditions in many fields—petroleum, earth-moving, metalworking, rubber, paper, pulp and others.

Write our engineering department for a recommendation of the Fawick elements best suited for your machines. Address Dept. MD.

FAWICK CO., INC. Airflex

Expanding under force of compressed air, the rubber-and-fabric tube smoothly engages the clutch with the precise degree of grip required by the job.

Releasing air through the instant-acting Fawick Quick Release Valve promptly and fully disengages the clutch, lets it ride completely free, without drag, or mechanical contact.

Designer's

ANNOUNCING a complete ALL-NEW line

NEMA sizes 0, 1, 2, 3
for a-c motors up to 50 hp

MOTOR STARTERS

Designed for Easy Maintenance

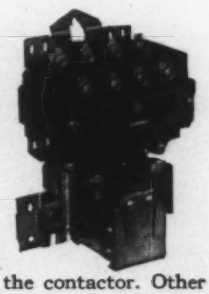
Built so you can forget them

GENERAL ELECTRIC

Digest

TIMELY HIGHLIGHTS ON GE PRODUCTS

ALL-NEW Magnetic Contactors



Plenty of new features will interest designers in these new G-E a-c contactors, available in NEMA sizes 00, 0, 1, 2 and 3. All terminals are accessible from the front and have large pan-head or slotted hex-head screws to speed wiring. Main poles in sizes 00, 0 and 1—and interlocks in all sizes—can be changed from normally open to normally closed with no extra parts needed. This facilitates last-minute changes and reduces need for stocking "specials." Extra two-circuit interlocks with interchangeable normally open to normally closed contacts can be added to either side of the contactor. Other new features include springs permanently attached to moving contact tips, lock washers fastened to all screws, and long-life magnet with permanent air gap. For easy inspection and maintenance, contacts can be completely exposed for inspection by loosening two screws to remove arc hood, contacts can be replaced without disturbing wiring, and coil is easily replaced by removing four screws which hold magnet in place. See Bulletin GEA-5154.

ALL-NEW Motor Starters

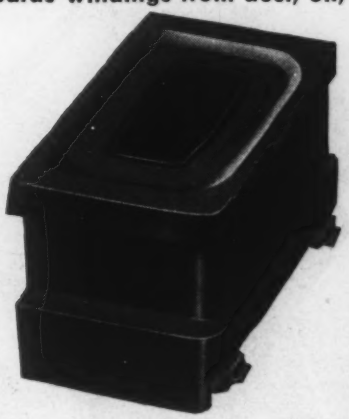
Check these G-E magnetic a-c starters on points that count with machinery manufacturers. Fine silver tips and extra-heavy construction of contacts mean extra long life. Molded, burn-resistant arc hood snuffs arcs at once—prolongs contact life. A flick of the finger changes the overload relays from hand to automatic reset. Available in non-reversing, reversing, and multi-speed types. See Bulletin GEA-5153.

ALL-NEW Combination Starters

A single, compact unit, the new G-E combination magnetic starter saves space and installation time. The rotary-action fused disconnect switch meets all National Electric Code requirements for circuit isolation and short circuit protection. The magnetic starter with its overload relays give the quick response needed to protect your motor from overloads. Units are also available with circuit breakers or non-fusible switches, if desired. See Bulletin GEA-5156.

ALL-NEW 'Strongbox' Magnet Coil

safeguards windings from dust, oil, water



Here's the stout heart of this all-new General Electric line of contactors, starters, and combination starters. Compare it with others and you'll agree the "Strongbox" Magnet Coil is the toughest you've ever seen. For long life even under severe conditions, it's firmly locked in a molded plastic block that completely protects the Formex® windings against dust, oil, and water. A permanent lubricant keeps the moving structure ready for action at all times. Slotted edges in the block keep the magnet travelling in a straight line with minimum wear. Maintenance is quick and easy—permanently anchored terminals won't loosen from the coil, and screwdrivers can't damage windings during wiring.

General Electric Company, Section B668-67
Apparatus Department, Schenectady 5, N. Y.

Please send me the following bulletins:

- ☐ GEA-5153—A-c motor starters
- ☐ GEA-5154—A-c contactors
- ☐ GEA-5156—Combination a-c starters

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS! You'll find "everything electric" for machinery manufacturers in the General Electric section.

Name.....

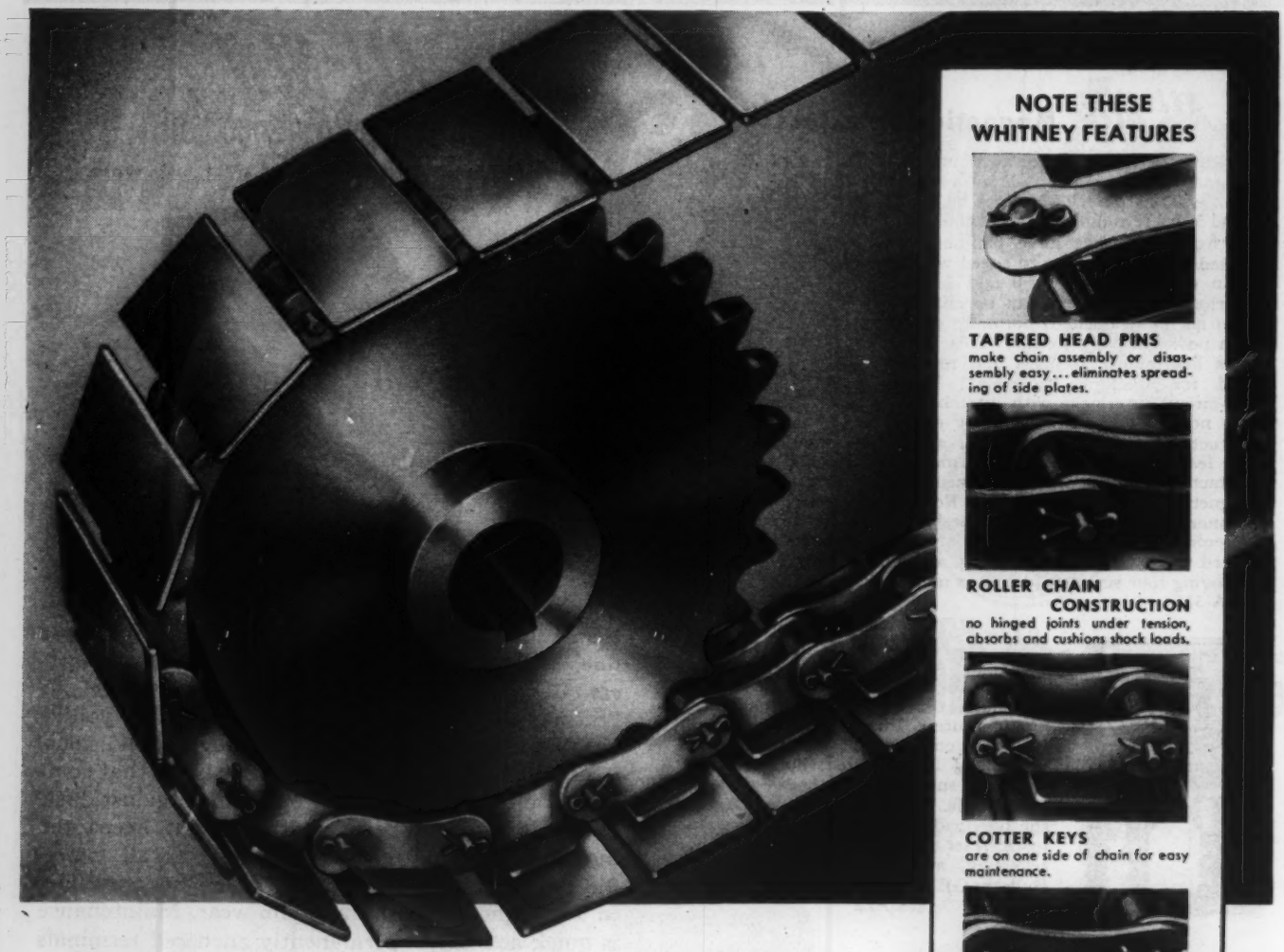
Company.....

Street.....

City.....**State**.....

Announcing

THE NEW WHITNEY
Platform Conveyor Chain
For Unit Conveying of Bottles, Cans, Small Package Goods

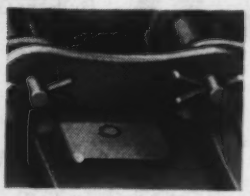


NOTE THESE WHITNEY FEATURES

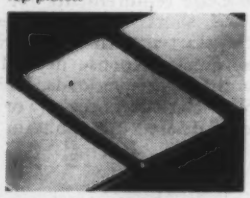
TAPERED HEAD PINS
make chain assembly or disassembly easy... eliminates spreading of side plates.

ROLLER CHAIN CONSTRUCTION
no hinged joints under tension, absorbs and cushions shock loads.

COTTER KEYS
are on one side of chain for easy maintenance.



ALL WELDED CONSTRUCTION
elimination of rivets makes it easy to keep chain clean. Assures level top plates.



NEW BEVELED EDGE
top plates have new edges for smooth, sure transfer from one conveyor to another.

Again Whitney leads in chain design with the new Platform Conveyor Chain! This new construction assures smooth, steady travel for all types of bottle and package materials, regardless of length or speed of conveyor line. It will help you to maintain production by reducing traffic jams, spillage and breakage.

Whitney Platform Conveyor Chain is manufactured in various widths and materials of platform plates, covering all requirements of conveying.

Whitney Silent and Roller Chains, plus Cut Tooth Sprockets . . . the all steel drives . . . simplify your power transmission designs. Specify Whitney for dependable, smooth operation and long life. Write for information.

WHITNEY CHAIN & MFG. CO.
Division of Whitney-Hanson Industries, Inc.
205 HAMILTON STREET, HARTFORD 2, CONN.

9 times in 10
it starts with
R/M

R/M clutch facings are used as standard equipment by *both* of the "big two" in the motorcycle field . . . companies whose combined output represents 9 out of every 10 motorcycles sold today!

This, you will agree, gives R/M unique experience in one type of high-speed transmission. More interesting, however, is the fact that R/M offers equally broad experience in practically every facet of friction material application . . . brake linings and brake blocks as well as clutch facings and special compositions for specialized purposes.

No matter what the size of the clutch you have in mind, no matter how much work you want it to do, no matter whether you want it to run dry or in oil . . . ask your R/M representative for help. He knows his business. He'll welcome the chance to work on your problems. And he'll call, when needed, on the full experience of four great plants, four complete research staffs, and four testing laboratories . . . all integrated parts of the R/M organization . . . the world's largest producer of friction materials.

RAYBESTOS-MANHATTAN, INC.

EQUIPMENT SALES DIVISION **620 Fisher Bldg., Detroit 2, Mich.**

445 Lake Shore Drive, Chicago 11, Ill.
714 W. Olympic Blvd., Los Angeles 15, Calif.
1017 Union Commerce Bldg., Cleveland 14, Ohio

Factories: Bridgeport, Conn. Manheim, Pa. Passaic, N. J. N. Charleston, S. C.

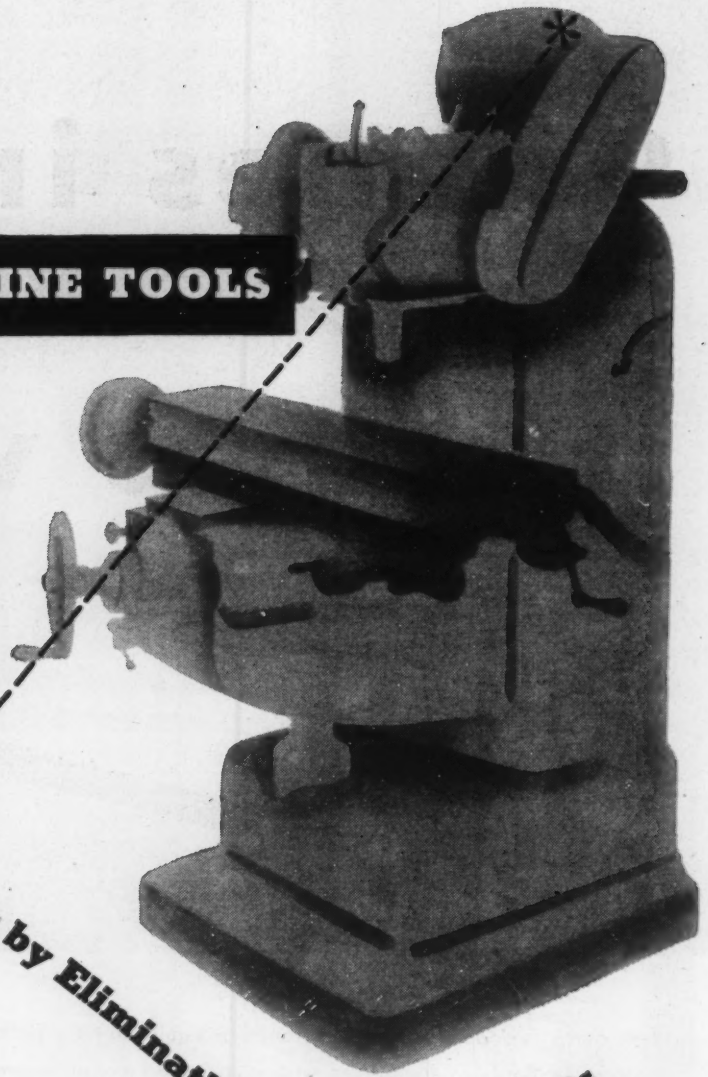
RAYBESTOS-MANHATTAN, INC., Manufacturers of Brake Linings • Brake Blocks • Clutch Facings
Fan Belts • Radiator Hose • Mechanical Rubber Products • Rubber Covered Equipment • Packings
Asbestos Textiles • Powdered Metal Products • Abrasive and Diamond Wheels • Bowling Balls

R/M

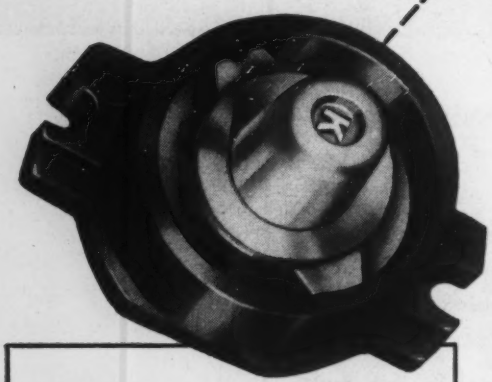
FIRST IN FRICTION

IN MOTORS FOR MACHINE TOOLS

KLIXON PROTECTORS



Keep Equipment Operating by Eliminating Motor Burnouts



One of the major causes of motor burnouts in machine tools is overloading of the machine. This causes the motor to dangerously overheat and burnout.

You can keep production going and reduce down time of lathes, drills, milling machines, etc., by specifying and using motors with built-in Klixon Protectors.

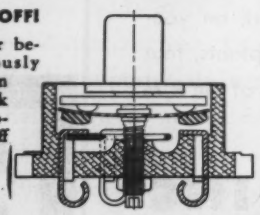
Because Klixon Protectors are built-in by the motor manufacturer and placed where they can watch overheating, they prevent the motor from burning out by cutting off the power as soon as the motor reaches a dangerous temperature. When it cools to safety, the protector snaps on the power again either automatically or by manual reset depending on the type of protector used.

Remember, too, Klixon Protectors prevent burnouts in other equipment such as transformers, solenoids, and adjustable transformers. So to keep your equipment operating, always use motors with Klixon Protectors.

HERE'S HOW IT WORKS

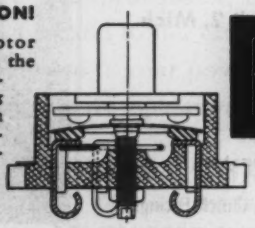
CLICK . . . IT'S OFF!

Should a motor become dangerously overheated from any cause, click the Klixon Protector snaps off the power automatically.



CLICK . . . IT'S ON!

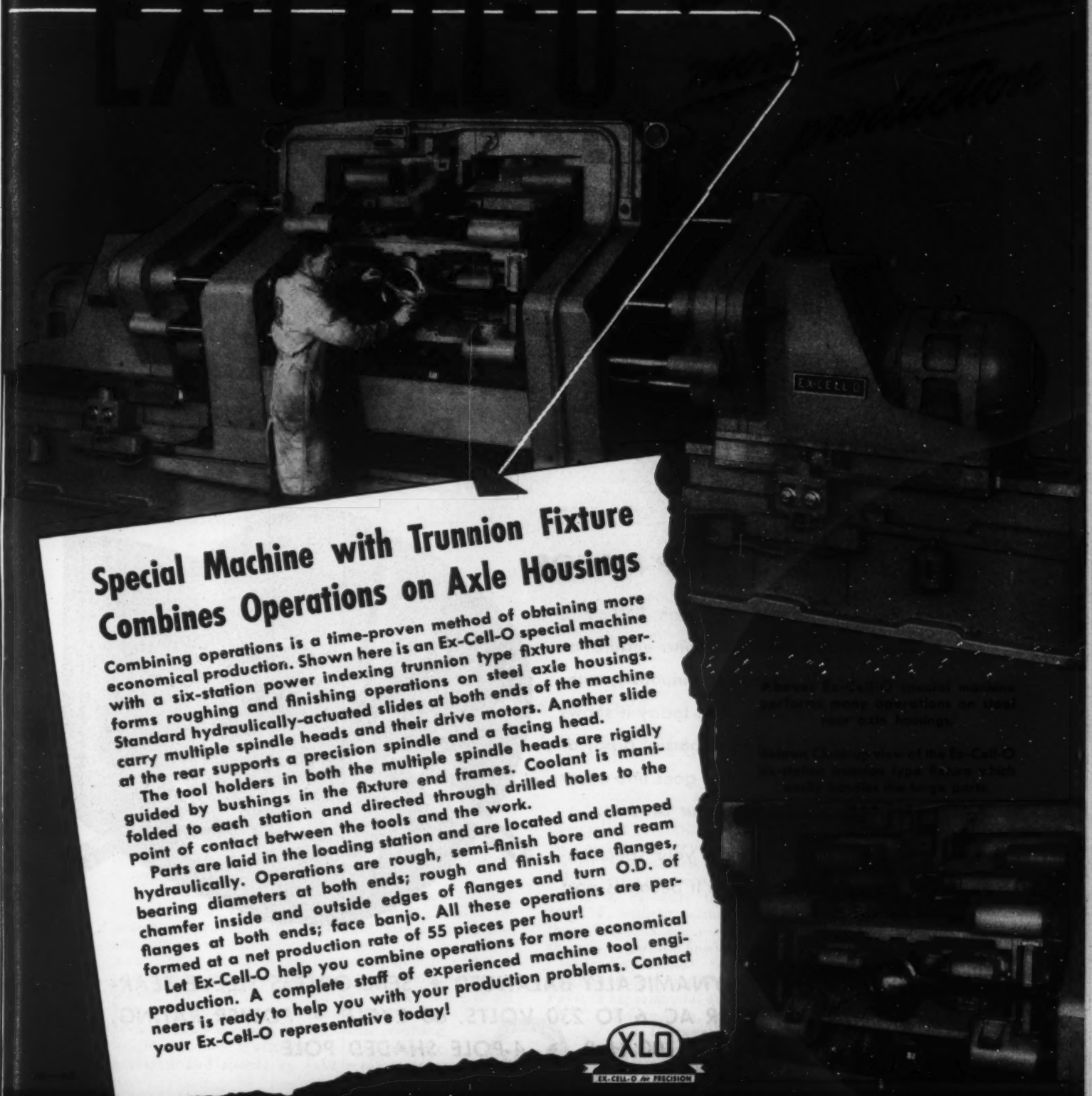
When the motor cools to safety, the circuit is re-established by pressing the red button on the manual protector or automatically when the automatic type is used.



KLIXON

SPENCER THERMOSTAT COMPANY

2501 FOREST STREET, ATTLEBORO, MASS.



Special Machine with Trunnion Fixture Combines Operations on Axle Housings

Combining operations is a time-proven method of obtaining more economical production. Shown here is an Ex-Cell-O special machine with a six-station power indexing trunnion type fixture that performs roughing and finishing operations on steel axle housings. Standard hydraulically-actuated slides at both ends of the machine carry multiple spindle heads and their drive motors. Another slide at the rear supports a precision spindle and a facing head.

The tool holders in both the multiple spindle heads are rigidly guided by bushings in the fixture end frames. Coolant is manifolded to each station and directed through drilled holes to the point of contact between the tools and the work.

Parts are laid in the loading station and are located and clamped hydraulically. Operations are rough, semi-finish bore and ream bearing diameters at both ends; rough and finish face flanges, chamfer inside and outside edges of flanges and turn O.D. of flanges at both ends; face banjo. All these operations are performed at a net production rate of 55 pieces per hour!

Let Ex-Cell-O help you combine operations for more economical production. A complete staff of experienced machine tool engineers is ready to help you with your production problems. Contact your Ex-Cell-O representative today!

XLO

EX-CELL-O for PRECISION

EX-CELL-O CORPORATION

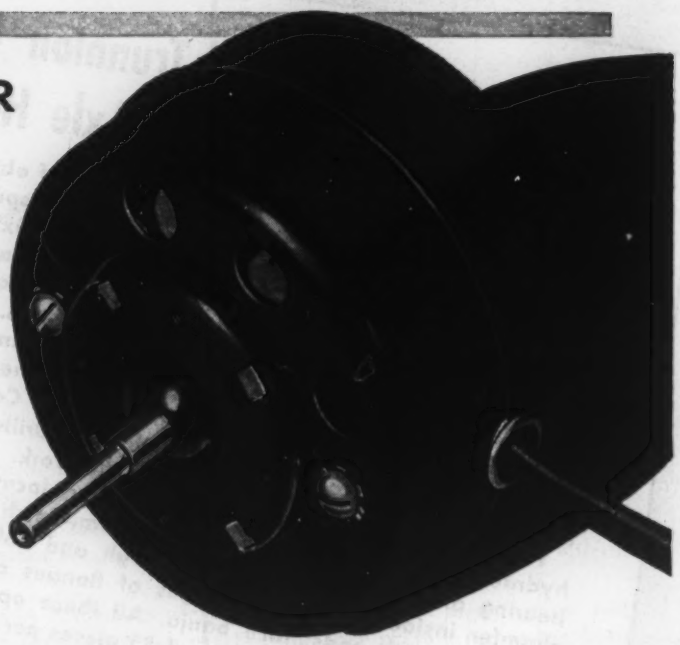
Detroit 32, Michigan

Special Multiple Way-Type Precision Boring Machines • Special Multiple Precision Drilling Machines • Precision Boring, Turning, and Facing Machines and Fixtures • Precision Cylinder Boring Machines • Precision Thread Grinding Machines • Precision Lapping Machines • Precision Broach Sharpening Machines • Other Special Purpose Machines • Tool Grinders • Continental Cutting Tools • Broaches and Broach Fixtures • Counterbore Sets • Grinding Spindles • Hydraulic Power Units • Drill Jig Bushings • R.R. Pins and Bushings • Fuel Injection Equipment • Dairy Equipment • Aircraft and Miscellaneous Production Parts

EMC's No. 800-B FHP MOTOR

More than seven years ago an EMC No. 800-B was started on a lifetime endurance test. Since then it has run continuously, without any kind of service. And today it shows no sign of faltering. This is partial proof of the superior engineering that goes into every EMC motor built to power *your* product.

No. 800-B is made to meet your specifications. It is so expertly fitted it becomes part of your device.



PRECISION BUILT • DYNAMICALLY BALANCED • SEMI-OILLESS SLEEVE BEARINGS • WINDING FOR AC, 6 TO 230 VOLTS, 60 CYCLE • POWER RATING, UP TO 1/100 H. P. • 4-POLE SHADED POLE

For complete details, ask for Bulletin No. 800.

TRADEMARK EMC REGISTERED

CUSTOM-BUILT FRACTIONAL H.P. MOTORS FOR ALL INDUSTRY

ELECTRIC MOTOR CORPORATION

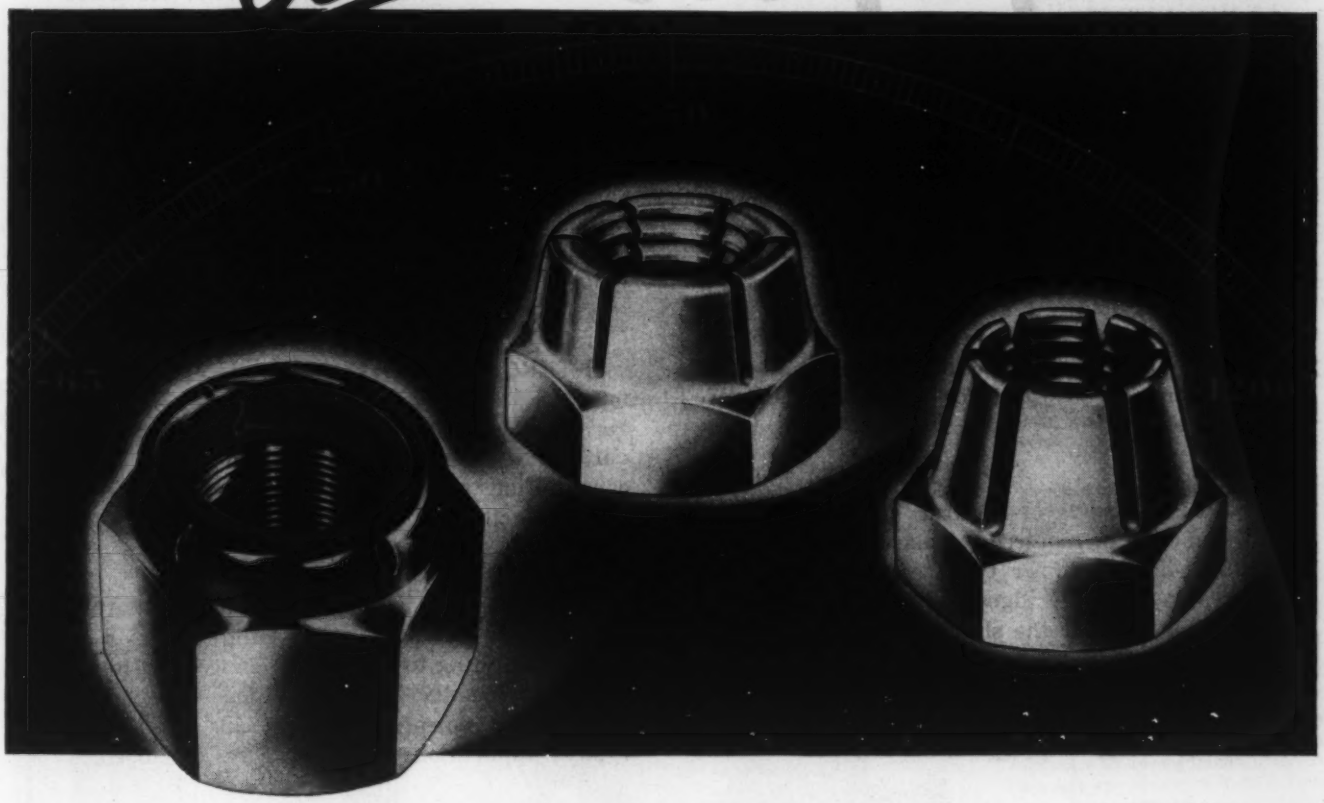
DIVISION OF HOWARD INDUSTRIES

RACINE, WISCONSIN

NOW!

ESNA spans the temperature field

-65°F to +1200°F with SELF-LOCKING ELASTIC STOP NUTS



—famous Elastic Stop Nuts protect permanently against VIBRATION! IMPACT!

With the addition of the new Z-550 and Z-1200 series, ESNA now has a specific nut design for all temperatures ranging from minus 65° F. to plus 1200° F. Self-locking, in both fully seated and positioned settings, these fasteners provide permanent protection against *vibration, impact* and *stress reversal.*

The two new nut designs represent the most efficient solution found by ESNA engineers after detailed research and production line studies of fastening problems encountered under elevated temperatures. Both fully meet ESNA standards for controlled quality and full interchangeability on class 3 bolts with minimum torque scatter. This controlled torque which is a feature of all ESNA nuts assures uniform bolt loading and permits more compact design, with resulting weight reduction. It also simplifies maintenance problems and speeds up field replacements.

Specifically, for applications between −65° F. and +250° F., the nut with the famous red fiber collar offers unequalled protection against vibration, thread corrosion and liquid seepage. The ZM and ZE nuts are designed for sustained temperatures up to 550° and the Z-1200 series has been engineered to withstand multiple cycles of exposure to extreme temperatures up to 1200° F. without seizure. Like all Elastic Stop Nuts, these fasteners are readily removed—do not damage threads or gall the finish—and they can be reused.

HERE'S A CHALLENGE: Send us complete details of your toughest bolted trouble spot. We'll supply test nuts—FREE, in experimental quantities. Or, if you want further information, write for literature. Elastic Stop Nut Corporation of America, Union, N. J. Representatives and Agents are located in many principal cities.

ESNA TRADE MARK

ELASTIC STOP NUTS

HIGH TENSILE

ANCHOR

WING

SPLINE

CLINCH

GANG CHANNEL

NYLON CAP

OVER 450 TYPES AND SIZES IMMEDIATELY AVAILABLE FROM STOCK

Topics

PLASTIC FILM resembling Scotch tape in appearance has been developed by Minnesota Mining & Manufacturing for bonding metal to metal. The film is placed between surfaces and bonds are obtained at temperatures of 300 to 500 F and pressures between 25 to 100 psi for 5 to 60 minutes. Aluminum to aluminum shear strengths of 3500 psi for 1/16-inch sheet are reported.

ZIPPER conveyor-elevator belts operate flat or tubular as required. Edges of the belt are provided with zipper type serrations which intermesh when the edges of the belt are brought together. Under the slight compression formed in "zipping-up" the belt, granular material may be carried and elevated in any plane including vertical.

VALVES, long standardized, have yielded to research and design, resulting in the development of a new line of cast steel valves. It is said that flow has been increased 30 per cent and pressure loss lowered 40 per cent.

LAPPED OR SHAVED gears, according to Westinghouse tests, increase resistance to pitting while ultimate ability to carry load is affected but little. The tests also proved that long run-in periods of operation at light load to achieve work hardening of the tooth surfaces are not necessary to develop high load-carrying ability.

PHOSPHATE FILM on ferrous metal parts is produced from a water solution of powder Detrex 79, made by the Detrex Corp., which removes light soils and oil film and deposits the phosphate base for paint coating.

NEW SYNTHETIC fiber, called Orlon, has a combination of properties which nylon and rayon will not equal, according to the Du Pont Co. Probable industrial applications include filter fabrics, electrical insulation, belting and diaphragm fabrics. High dry and wet tensile strength, high resistance to stretching, high flex life, rapid drying, bonding to resins and rubbers, dimensional stability to heated gases and liquids, resistance to acid and acidic fumes at high temperatures, and resistance to insects, molds and mildew are characteristics of the acrylic fiber.

INTEROFFICE television, produced by Remington Rand, may prove useful in checking or verifying details of a drawing in the vault without the necessity of obtaining a print. Also consultation between engineering departments may be facilitated.

ULTRASONICS when applied to agriculture may result in some very significant developments, according to General Electric Co. Homogenizing of milk, improving seed germination and killing harmful bacteria and fungi are typical applications which may be developed.

REVERSIBLE-PITCH propellers enable multiengine airplanes to descend at rates exceeding 10,000 feet per minute with air speeds below 200 miles an hour. Flight-test program at Curtiss-Wright shows that the plane's rate of descent may be doubled without increasing its forward speed or imposing extraordinary stress upon its structure.

HIGH-SPEED motion pictures of casting process reveal that no ordinary gating system prevents turbulence in the mold. In systems using multiple-finger gates best results are obtained when total finger area equals that of the sprue, according to Johnson and Baker in *Foundry*, Oct., 1948.

LEATHER applications have been handicapped through the lack of data on such properties as expansivity, compressibility, dry density, and specific heat. Research, sponsored by the Office of Quartermaster General, disclosed that the average expansivity of 0.00054 per degree Cent. applies for all leathers except chrome-vegetable leather which is 0.00034.

Idea that turns the heat on sales

And what an idea . . . for something *new* in a cooking range!

For this smart new gas range is a *heater,* too. Just press a button, turn a valve, and a special unit quickly warms the kitchen on a chilly day!

Again, double-walled Bundyweld* Tubing shares in a bright idea that puts the heat on a manufacturer's sales. For the supply lines and flash and pilot tubes in this sleek appliance are Bundy Tubing, a stand-by in the gas range field.

Whether *you* make toys or trucks, there could easily be an idea in Bundy for you as well. For you'd be amazed at *where* you can use Bundy Tubing.

The examples at the right are only *hints.* They range from standard uses for Bundy to possible ways *you* might spark real sales. Look them over now.

BUNDY TUBING

ENGINEERED TO YOUR EXPECTATIONS

*REG. U.S. PAT. OFF.

6 All of the actual Bundy applications shown on this page began with an idea of using Bundy. By the same token, you may easily find the answer to a smarter, lighter-weight, longer-lasting product, turned out more easily and at less cost, through checking Bundy. Why not try. Our engineers will be glad to give you a hand. Just call or write *Bundy Tubing Company, Detroit 14, Michigan.*

WHY BUNDYWELD IS BETTER TUBING

Bundyweld Tubing, made by a patented process, is entirely different from any other tubing. It starts as a single strip of basic metal, coated with a bonding metal.

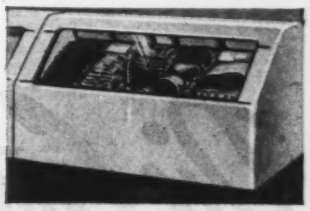
This strip is continuously rolled twice laterally into tubular form. Walls of uniform thickness and concentricity are assured by close-tolerance, cold-rolled strip.

Next, a heating process fuses bonding metal to basic metal. Cooled, the double walls have become a strong, ductile tube, free from scale, held to close dimensions.

Bundyweld comes in standard sizes, up to 5/8" O.D., in steel (copper or tin coated), Monel or nickel. Special sizes can be furnished to meet your requirements.

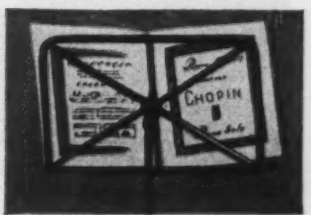
Bundy Tubing Distributors and Representatives: *Cambridge 42, Mass.:* Austin-Hastings Co., Inc., 226 Binney St. • *Chattanooga 2, Tenn.:* Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • *Chicago 32, Ill.:* Lapham-Hickey Co., 3333 W. 47th Place • *Elizabeth, N.J.:* A.B. Murray Co., Inc., Post Office Box 476 • *Philadelphia 3, Penn.:* Rutan & Co., 404 Architects Bldg. • *San Francisco 10, Cal.:* Pacific Metals Co., Ltd., 3100 19th St. • *Seattle 4, Wash.:* Eagle Metals Co., 3628 E. Marginal Way • *Toronto 5, Ont., Canada:* Alloy Metal Sales, Ltd., 881 Bay St. **Bundyweld nickel and Monel tubing is sold by International Nickel Company distributors in all principal cities.**

1 Push a button and this convertible top *glides* up or down. For its hydraulic pressure lines are strong, dependable Bundyweld* Tubing. Hydraulic brake line systems in 95% of today's cars are Bundy, too!

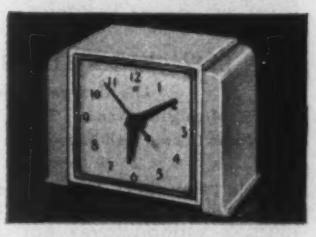


2 Look for Bundy wherever there's refrigeration, as well. Bundy tubing is fast-cooling, easily fabricated, ductile, long-wearing . . . unbeatable for coils, condensers and refrigerant lines where performance counts.

3 One manufacturer uses Bundy as a case and holder for thermometers. Others make awning frames, umbrella stems, spray nozzles of Bundy. Your idea may pay off with a use of Bundy too. Speaking of ideas . . .



4 It seems as though Bundy would be ideal for strong, light-weight music racks. We don't *know,* but if you're interested we'll be glad to work with you. (Bundy is *already* being used for camera tripods.) Then, too . . .



5 Perhaps clock makers should check on Bundy for hour and minute hand shafts. Ditto meter and gauge manufacturers who need dependable, rugged, tubing parts for all types of precision instruments.

Die Casting by —

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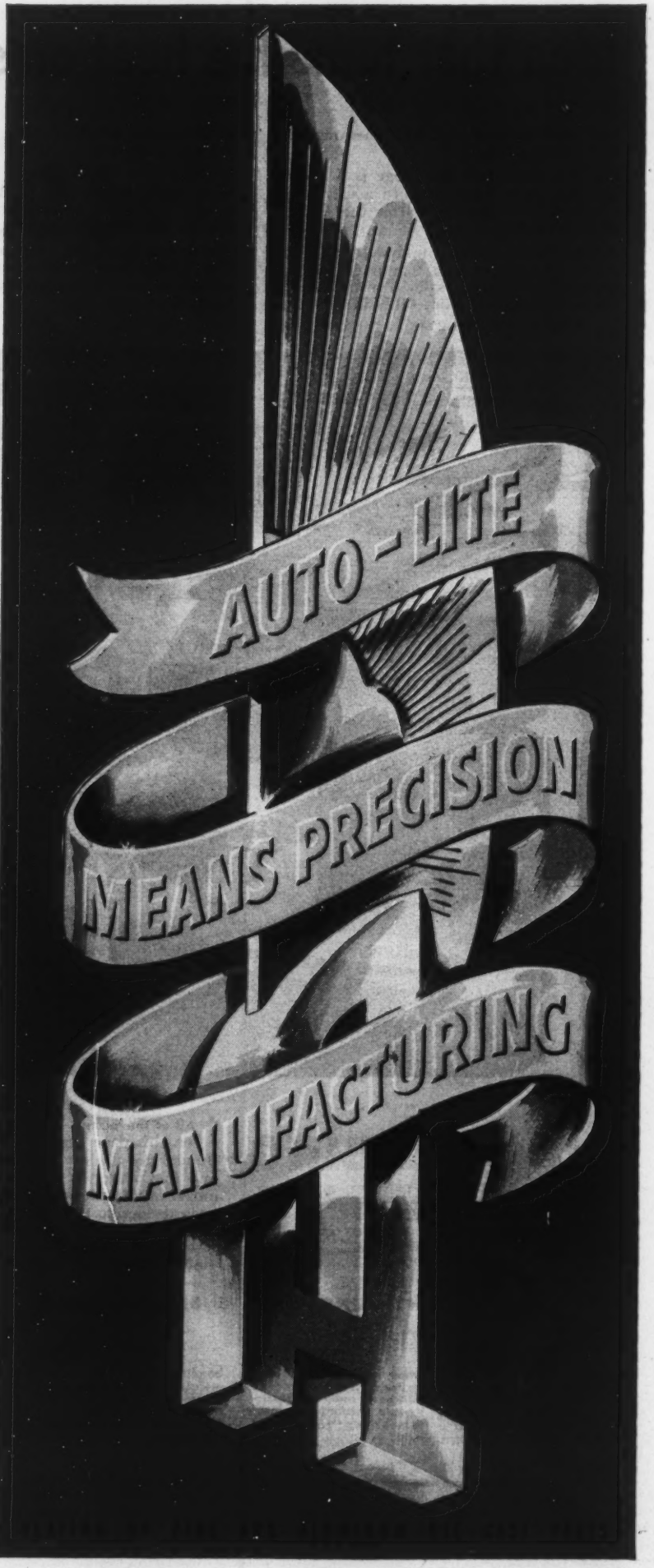

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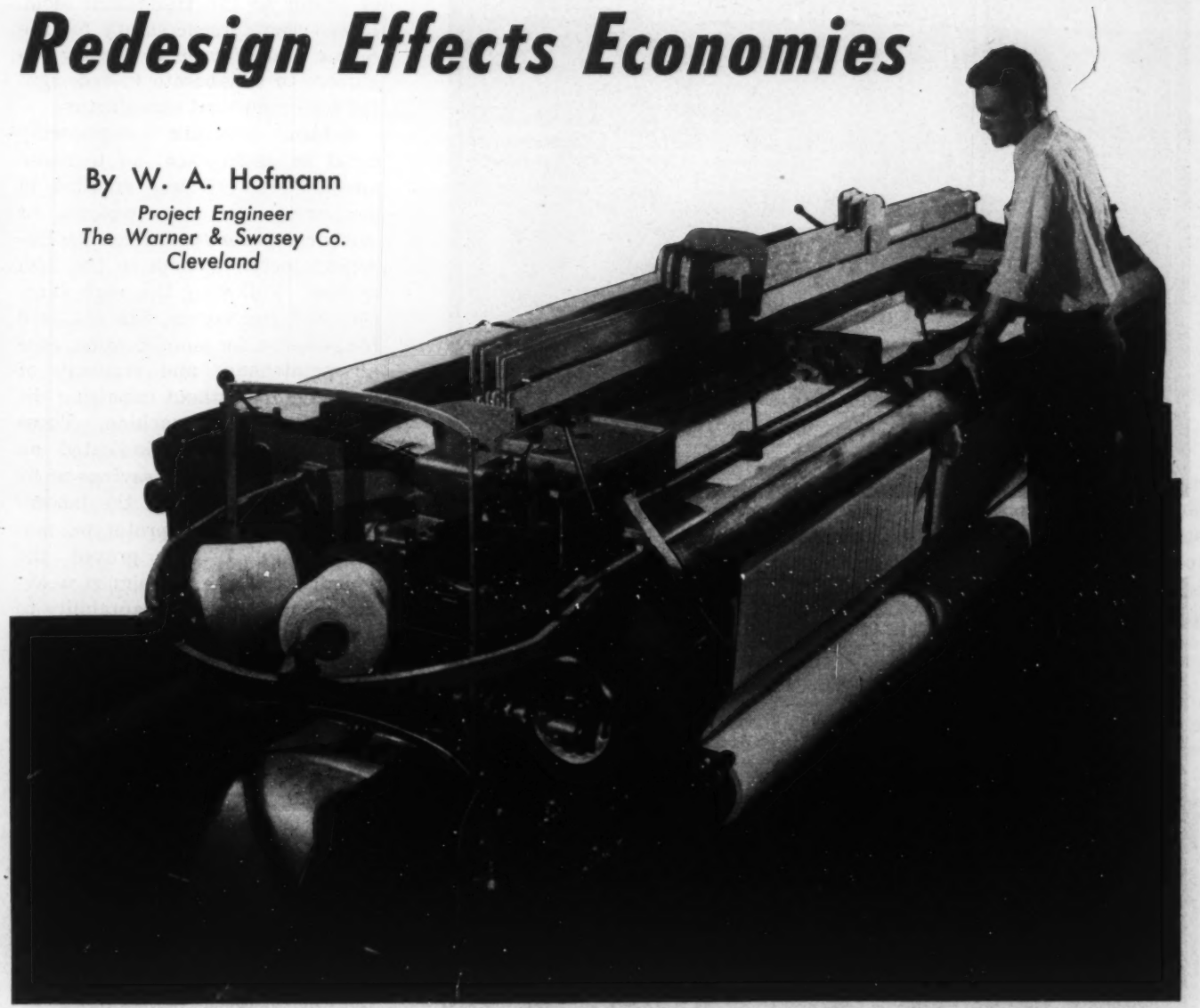
CASTING, MACHINING, FINISHING AN

MACHINE DESIGN

Redesign Effects Economies

By W. A. Hofmann
Project Engineer
The Warner & Swasey Co.
Cleveland



IN REDESIGNING the Swiss-made Sulzer weaving machine for production, each individual component of the machine was analyzed on the basis of economical manufacture by American mass-production methods. The Swiss machine, although a fine example of sound design and precision workmanship, was a pilot model developed with the primary object of proving design and functions, cost of

Fig. 1—Redesigned for mass production, the revolutionary Warner & Swasey-Sulzer loom can be built for less than half the cost of duplicating the laboratory design. Stamped parts are utilized extensively

Fig. 2—Expensive segment gear and drive racks for operating each harness on the laboratory machine

manufacture necessarily being of secondary importance. In its original form it could not be built to compete with conventional machines in the American market although it embodied revolutionary principles and represented the most significant advance in the weaving art since the application of power to the traditional loom. It was therefore necessary for the Sulzer and Warner & Swasey engineers to collaborate in redesigning for economical manufacture.

Before intensive engineering could be undertaken, an immense amount of work was entailed in converting the measurements of every component part from the European metric system to the inch system. Following this each function and mechanism was analyzed for redesign for simplification, ease of maintenance and economy of manufacture without impairing the functions of the machine. These engineering studies indicated an estimated production savings of 57 per cent over that of the laboratory design. The prototype machine, *Fig.* 1, has proved the soundness of the redesigned weaving machine and its adaptability to American production methods.

Principal redesign factors influencing the production design were as follows:

1. Redesign for simplification of mechanism wherever possible
2. Design of components for mass production on automatic and special-purpose machines
3. Extensive use of stamped parts
4. Use of precision castings for intricate small parts
5. Utilization of furnace brazing methods
6. Use of unit type construction for machine elements
7. Elimination of adjustable links and eccentrics used at final assembly to compensate

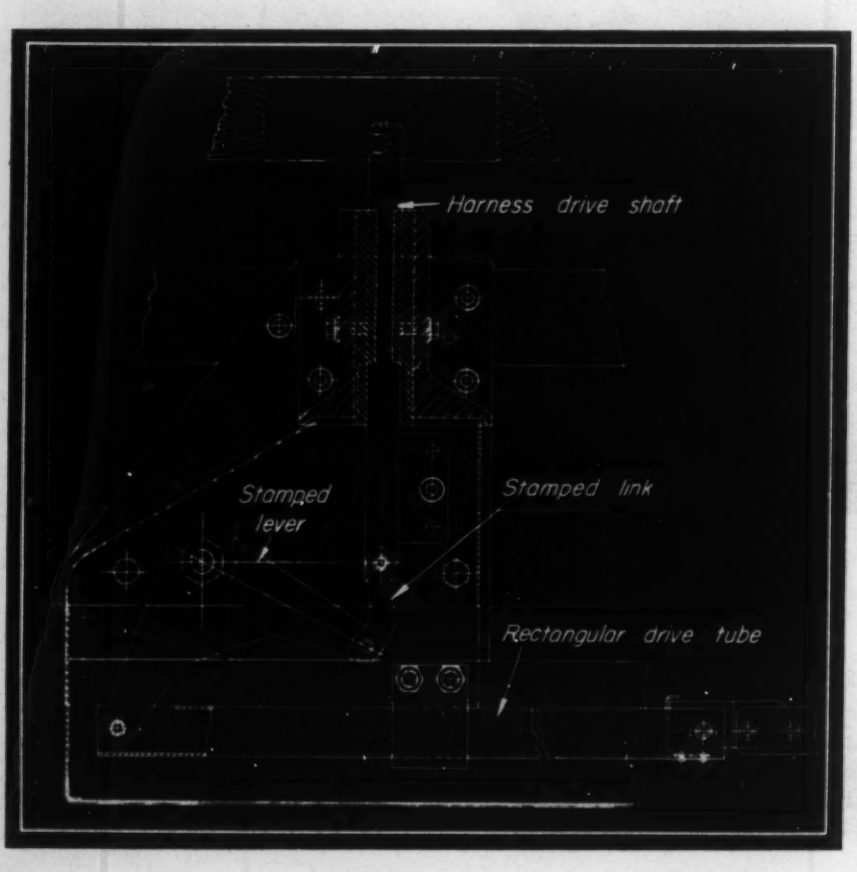


Fig. 3—Stamped lever and link replace the gear and rack drive shown in Fig. 2 for original machine

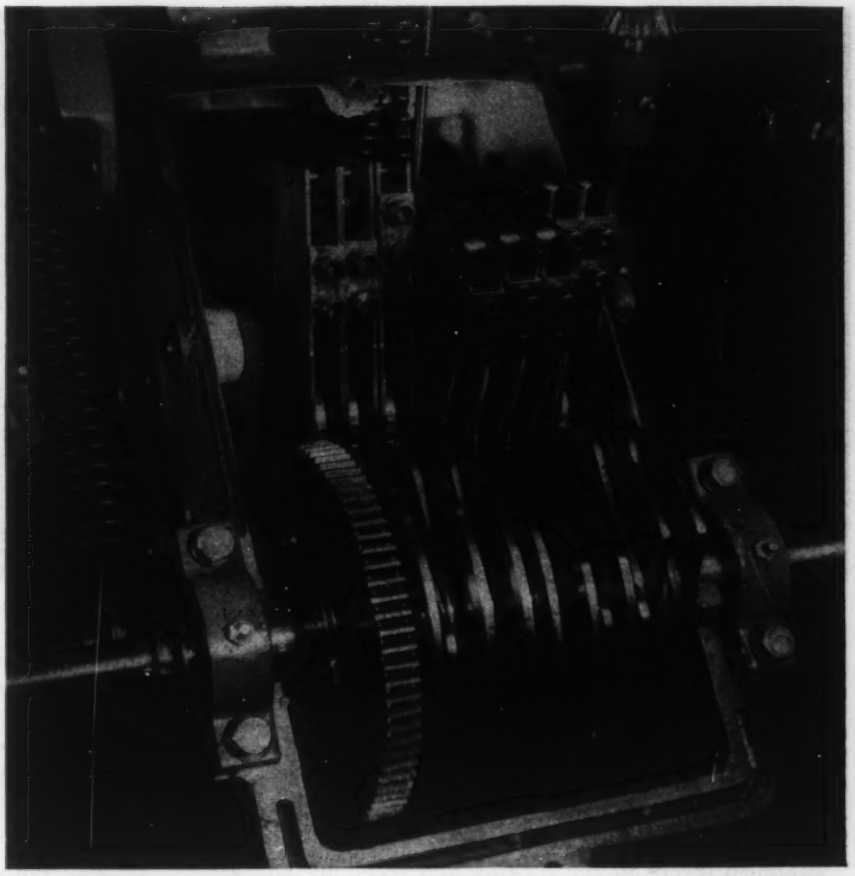


Fig. 4—Stamped cams actuate the harness drive illustrated in Fig. 3. Harness motion and shed opening are easily changed by positioning the cams and adjusting the followers

for cumulative variance in tolerances

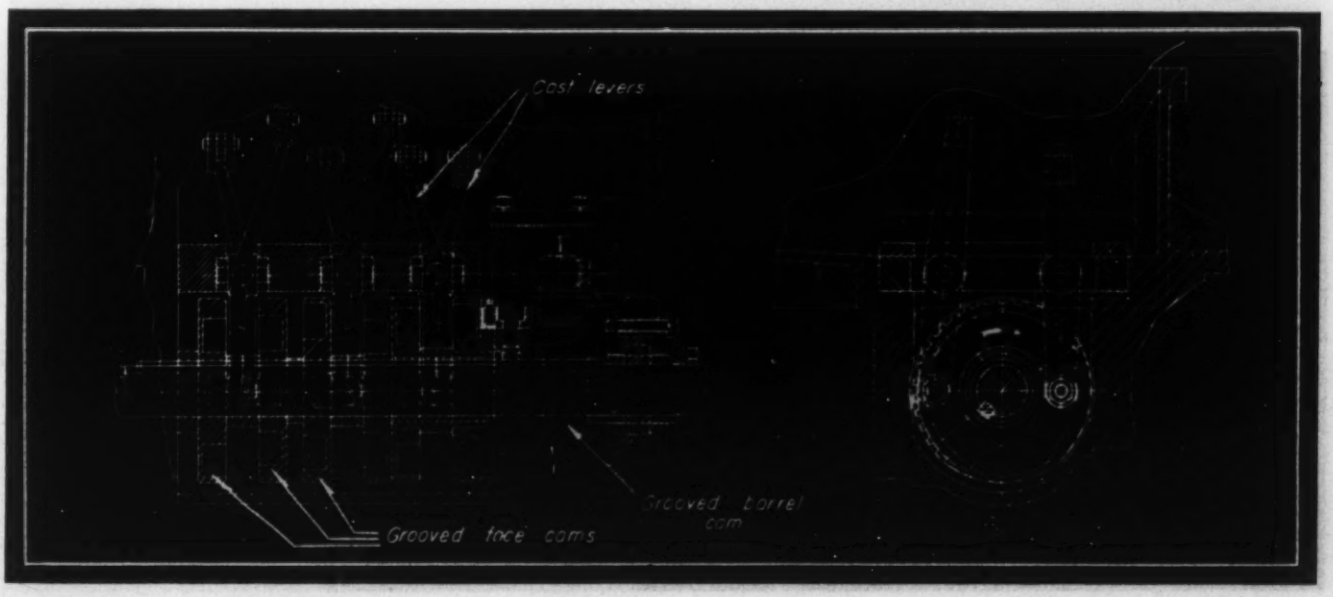
8. Standardization of similar parts of different groups
9. Reduction of mass of moving parts to decrease vibration and wear, making possible higher speeds
10. Use of alloy metals for greater strength and resistance to vibration and impact
11. Extensive utilization of anti-friction bearings

To indicate the extent and types of parts to which the foregoing design principles have been applied a few typical units will be discussed as well as the functional operation of the machine.

The original harness drive shown in *Fig.* 2 employed costly gear segments and special racks which are replaced by stamped levers and links in the redesigned unit, *Fig.* 3. Motion for the harness, which produces the shed in the warp, is actuated by cams running in oil and totally enclosed in a box, *Fig.* 4. Cover for this box is readily removed for access to the cams. Cams and their shafts are removable for changing by removing the caps on the shaft bearings. Eight harnesses are positively operated by these cams through levers as shown in *Fig.* 3.

Shuttle stopping, positioning, expulsion and detection are handled by elements in a compact receiving box. The original design of this unit, *Fig.* 5, employed grooved face cams and a grooved barrel cam with cast steel cam-roller levers. *Figs.* 6 and 7 show the redesign of this unit. Flat stamped cams, made by punching and shaving, and stamped levers replace the more costly grooved cams and cast levers. Not only are the redesigned cams less costly but they also have more inherent accuracy. To obtain oscillating motion at 90 degrees to the drive, the tappet arrange-

Fig. 5—Laboratory design of receiving box having grooved face cams and grooved barrel cam with cast iron cam roller levers. Redesigned unit is shown in Fig. 6



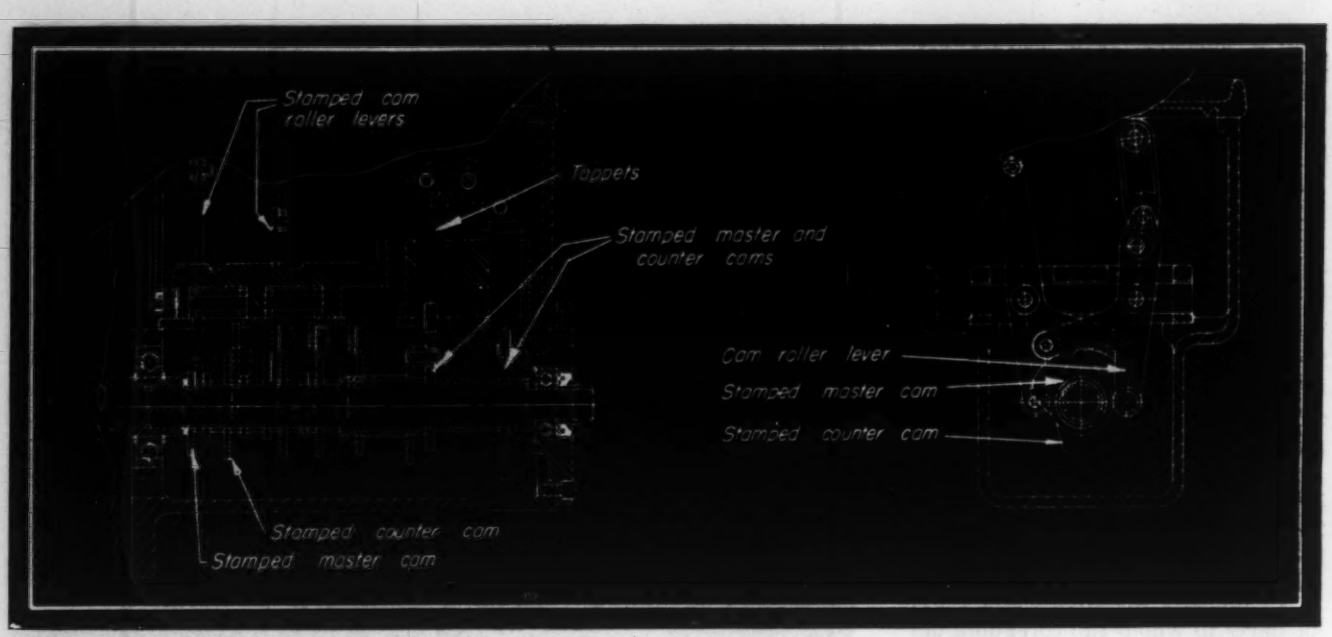


Fig. 6—Production design of receiving box uses stamped master and counter plate cams, giving a positive drive. Cam roller levers are also stamped. Noteworthy is the use of tappets to give oscillating motion to shaft at 90 degrees to drives obviating barrel cam

ment shown provides for the use of two simple cams instead of the former barrel cam.

Stamped levers in the picking and receiving boxes, harness drive and similar parts have furnace-brazed hubs, providing for economical manufacturing of the parts.

Tucking units of the laboratory design, *Fig.* 8, also employed a grooved face cam and a cast follower arm. The same motion is obtained in the redesign, *Fig.* 9, but from a simpler stamped plate cam and a stamped, spring-loaded follower.

In order to avoid machining operations and to utilize abrasion-resistant alloys on intricate working parts, extensive use of precision castings is being considered. Examples include parts in the picking and receiving boxes as well as conveyor drive, such as shuttle gripper, shuttle feeder, shuttle lifter, expeller box guide, and conveyor shoe. Shuttles, precision cast of beryllium copper, are being tested. Materials used for the other parts, depending on the operating conditions involved, are nickel steels or high-alloy steels.

Employs Unit Type Construction

Unit type construction of the machine simplifies assembly as well as removal of units for maintenance in the mill. For example, the harness drive, tucking units and receiving box which have been discussed are all unit assemblies and removable from the machine as such. Likewise the picking box, lay motion housings and shuttle conveyor are also of unit construction.

This machine eliminates completely the time-honored, bulky wooden shuttle containing a bobbin wound with yarn. Instead it utilizes a lightweight steel gripper-shuttle which grasps yarn from a large-ca-

Fig. 7—Shuttle stopping, positioning, expulsion, and detection are handled by compact receiving box

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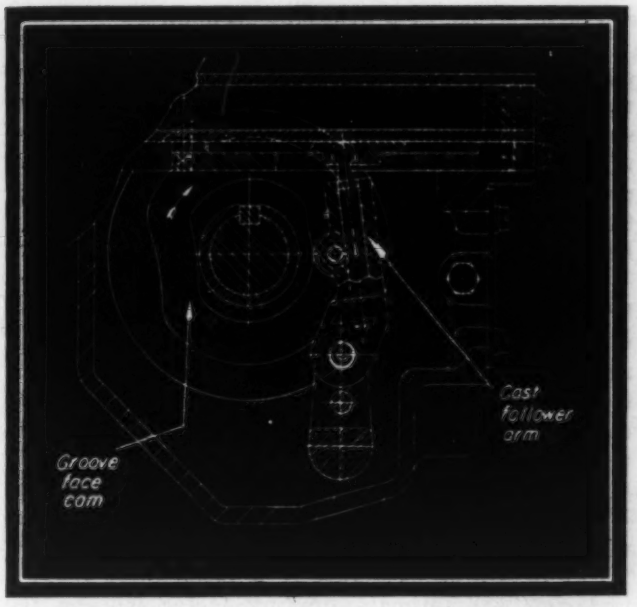


Fig. 8—Original laboratory tucking unit with grooved face cam and cast follower arm

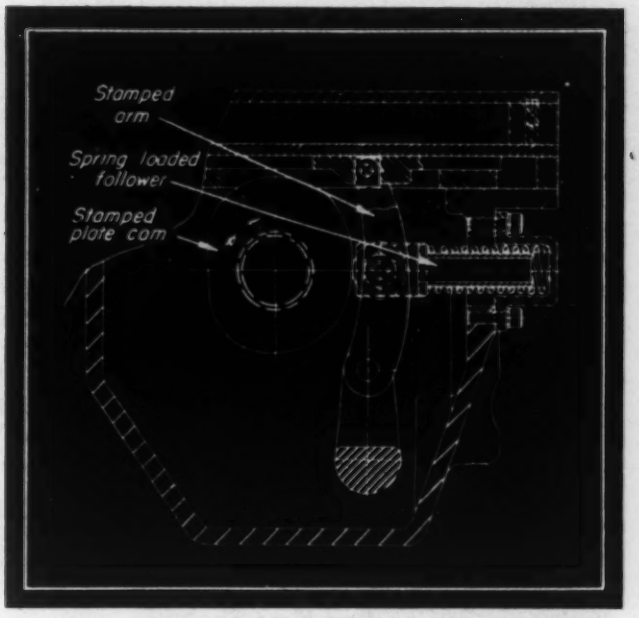


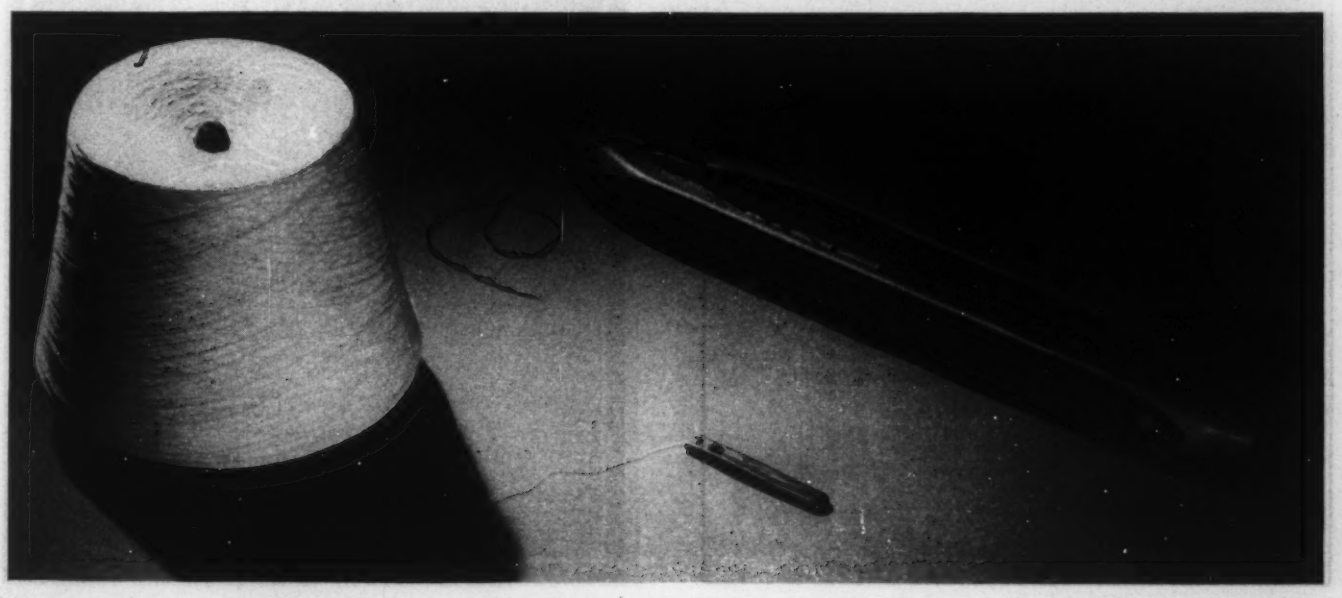
Fig. 9—Production design of tucking unit has stamped plate cam and stamped arm with spring-loaded follower

pacity wound-cone and carries it through the warp at high speed. *Fig.* 10 compares a conventional shuttle and its bobbin with the gripper-shuttle, and cone. Length of filling yarn thus unwound from the stationary cone is automatically held in the warp by tensioning arms while being cut from the cone, and the ends are tucked into the selvage, *Fig.* 11.

The shuttle is directed through the warp or shed by a series of steel guides, *Fig.* 12, and never touches the warp yarn, doing away with a source of yarn abrasion normally encountered. Continuous supply of filling yarn in large cones results in a sustained production of cloth without constant attention to bobbins, and also eliminates preliminary operations required in winding yarn on the numerous small bobbins. The outstanding innovation in the weaving process as carried out by this new machine is the method of inserting the filling and forming the selvage which is entirely different from that on the conventional loom.

Method of accomplishing this is shown in *Fig.* 11. In phase *a* the filling thread is taken from the cone through a thread tensioner and an oscillating tension arm to a thread feeder. A shuttle rises from its conveyor with its gripping fingers open into the position shown in phase *b*. The gripping fingers of the shuttle then close, gripping the end of the filling, and the fingers of the thread feeder open. The shuttle is then fired across the shed as in phase *c*, taking the filling with it. Meanwhile, the tension arm relieves the tension on the filling. In phase *d*, the shuttle in the receiving box is pushed back into a definite position,

Fig. 10—Small size of shuttle shown in comparison with conventional shuttle which carries a bobbin. Sulzer shuttle carries the filling thread from a stationary cone



the tension arm putting the required amount of tension on the filling. At the same time, the thread feeder advances to the position shown in phase *d*. Its fingers close as in phase *e*. At the same time, two grippers hold the filling while a pair of scissors cut it. The shuttle releases the end of the filling and is ejected onto the conveyor, as shown in phase *f*. The reed then pushes the filling into place, phase *g*, while the grippers maintain the filling under the desired tension. The thread feeder then returns to its original position, as shown in phase *h*, another shuttle is ready to come into position and the ends of the selvage are tucked in.

It can be seen that filling is never released and is always under perfect control. The shuttles are returned from the receiving to the picking position by a conveyor, which is comparatively slow-running. A number of shuttles are used on the loom, the quantity depending upon its width.

Torsion Rod Fires Shuttles

Shuttles are flipped rather than picked through the shed, *Fig.* 12, by a small lever operated by a torsion rod, which is loaded by a cam in the picking box. The amount of torsion on this rod is adjustable by a graduated head which protrudes through the front of the machine. The picking lever is checked at the end of its stroke by a hydraulic dashpot.

After passing through the shed, the shuttle is caught in the receiving box, where it is stopped by two adjustable brakes, and located exactly by a shuttle positioner. The gripping fingers are opened to release the end of the filling and the shuttle is pushed down onto a conveyor which runs underneath the shed and on which it is returned to the picking box.

Small size of the shuttle, together with the small lay motion and shed opening, *Fig.* 12, are some of the reasons why it is possible to greatly increase the speed of this machine over that of a conventional loom. Also reduction of mass of the moving parts, especially in the harness and lay drives, through the use of high-strength alloy steels contributed markedly to making the higher operating speeds possible. Machines have been operated at 240 picks for a machine of 110-inch width in the reed, and it is believed that the limit of speed has by no means been reached and that the ultimate limiting factor will be the strength of the filling yarn.

Fig. 11—Diagram illustrating eight phases of the picking action on the loom

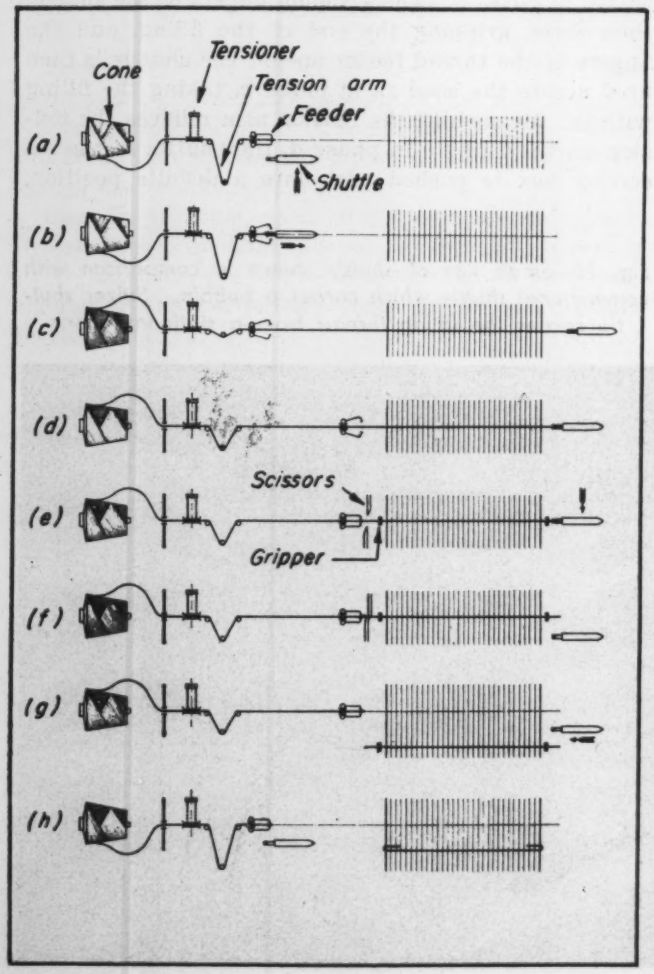
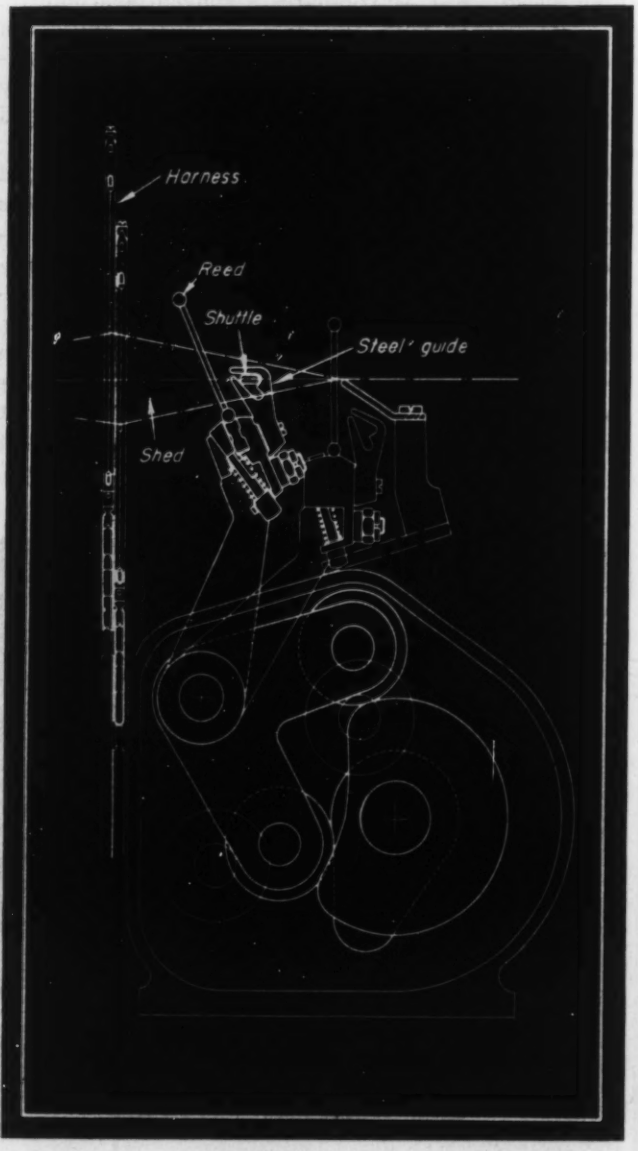
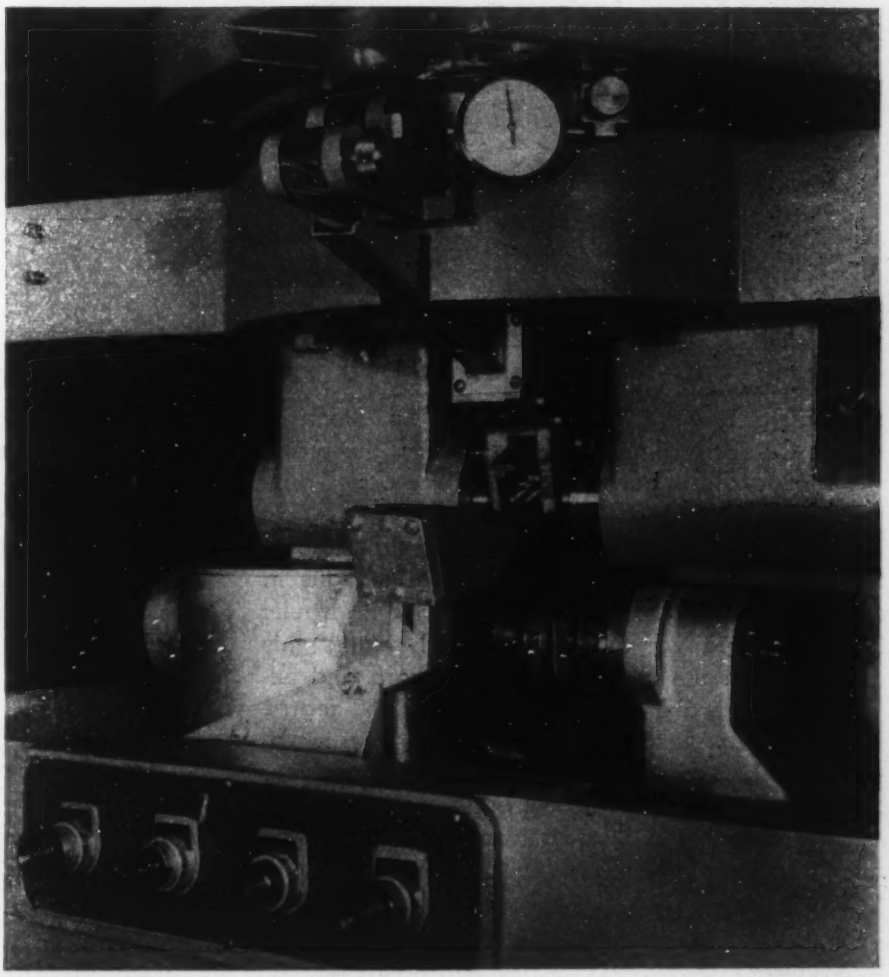


Fig. 12—Sketch showing how shuttle is guided through the shed without touching the warp yarn



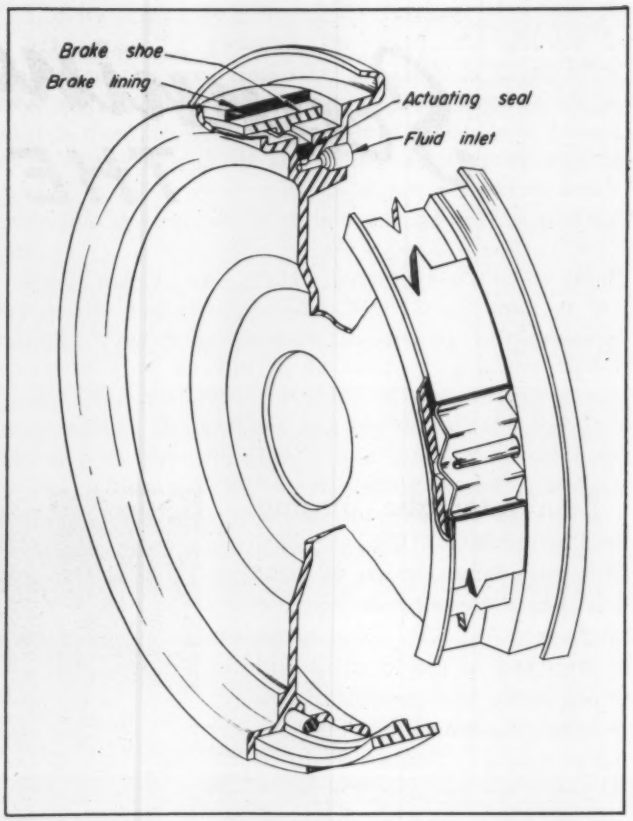
Scanning THE FIELD for Ideas

Semiautomatic gaging for the loader on the gear finishing machine shown at right has been developed by the Michigan Tool Co. The gage is attached at the loading end of the chute and consists of two gears so mounted that they revolve freely. Center distance between the two gaging gears is such that a pinion with an oversize pitch diameter, or one having excessive stock for best shaving results, will not drop between the gears into the chute. After dropping into the chute, the pinions are picked up one at a time by automatic arbors, shaved and ejected automatically.



Direct reading dial, below, indicates the number of complete revolutions of a screw feed, obviating mental counting by the operator. The dial, built by Van Dyke Instruments Inc., consists of two intergeared dials, the first is attached to the feed screw and reads in thousandths of an inch like a conventional dial and the second reads in tenths of an inch, indicating the actual number of turns.

Brake, utilizing hydraulic pressure on each segment of lining dispenses with the conventional wheel cylinder, pistons and linkages of standard

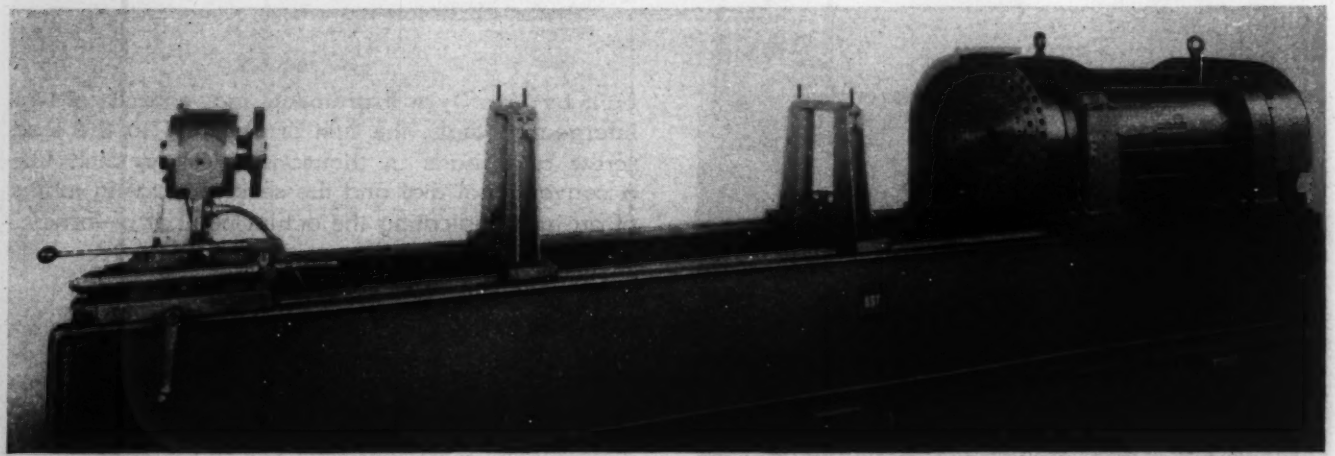


automotive brakes. Developed by The Glenn L. Martin Co. for airplanes during the war, the brake shown above has been tested on automobiles during the past two years.

As shown in the cutaway drawing at right above, the brake uses a continuous-ring seal that fits in a groove in the brake shoe support. Hydraulic fluid, actuated by the brake pedal, enters this groove under the seal, forcing it outward and expanding the brake shoes in virtually a 360-degree engagement with the drum. Full movement is obtained with relatively little fluid, allowing for sensitivity to pressure on the foot pedal.

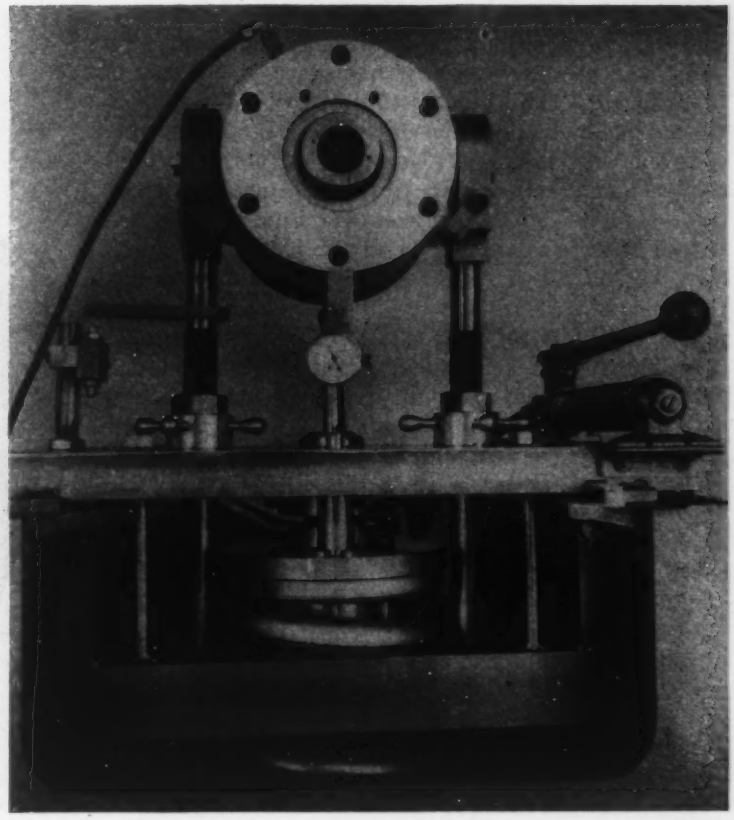
Shoe mounting is such that any degree of servo or self-actuation desired by the brake designer may be obtained. Equalizing movement of the shoe segments reduces the need for adjustment. Compensation for wear may be provided by limiting the return flow of fluid to the master cylinder, thereby effecting automatic adjustment. Present trend toward smaller wheels makes the features of this design attractive because of its extreme compactness.

Rotating-beam fatigue machine, below, built by the Baldwin Locomotive Works, tests pipe spans from 2 to 10 feet in length and up to 8⅝ inches in diameter under loads encountered in service. The



machine, having 1,200,000 in-lb capacity, has an overall length of 20 feet, width of 7½ feet and height of 4 feet. Pipe specimens, mounted as a cantilever beam in the machine, are subjected to bending loads and rotated in a horizontal position by a 20-hp motor at variable speeds up to 1000 rpm.

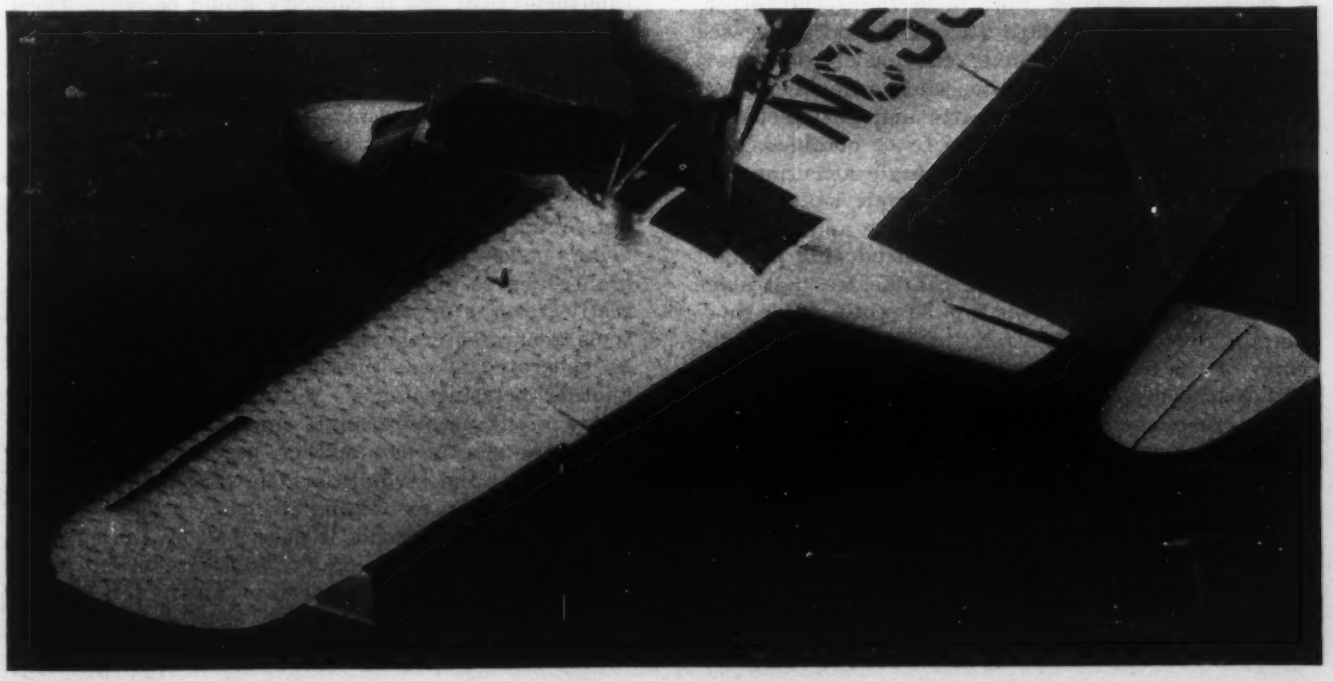
Load is applied by the mechanism shown at right consisting of a loading housing, dial indicator, microlimit switch, load applying and measuring spring, and a hydraulic hand pump for applying the load to the spring. Desired loading position is locked by two nuts.

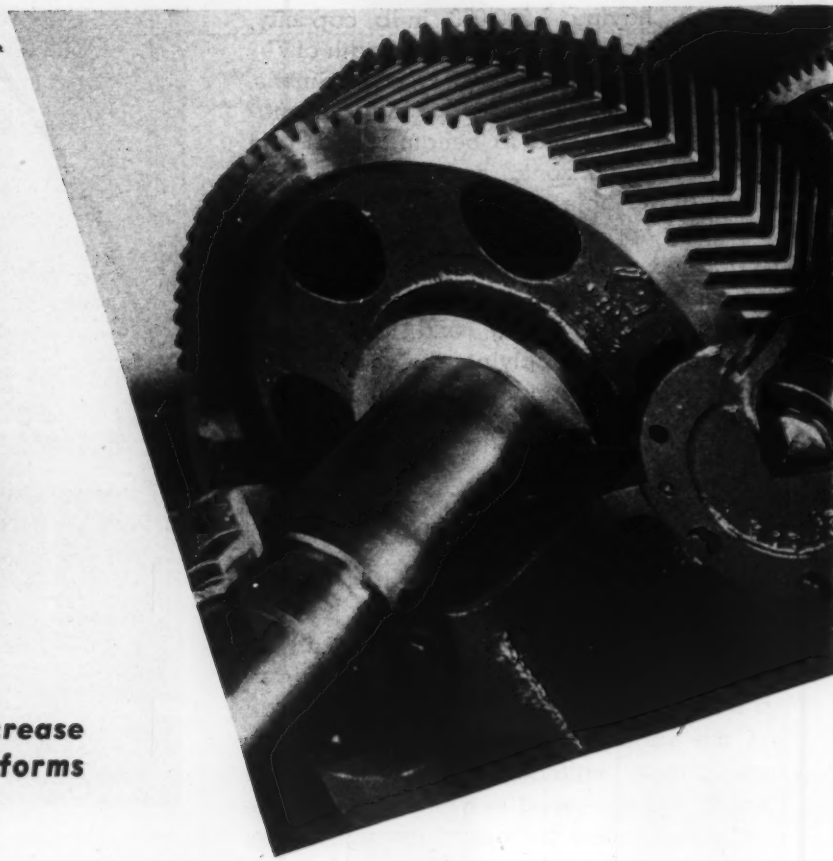


Air flow over the surfaces of aircraft under a variety of flight conditions is being studied at Goodyear Aircraft Corp. with the aid of a GA-2 experimental three-place amphibian airplane, below, having tufts of yarn on the surfaces under study. These tufts are four-ply knitting yarn four inches in length and are taped in even rows atop the left wing, on the bottom of the right wing, on the right side of the fuselage and the right wing float.

Direction in which the tufts blow as recorded by a movie camera give engineers a graphic picture of air flow about the ship. One of the first experiments completed under the program was to determine the effectiveness of wingtip slots in providing positive aileron control when the wing is stalled. In a normal stall the tufts show clearly that the turblence begins over the inboard portion of the wing, progressing steadily outboard to the slot. The tip area of the wing behind the slot remains unstalled with a smooth flow over the aileron, whereby normal aileron control is maintained.

Approximately 2000 individual strands of yarn were used in the experiment, black yarn being taped to the yellow portions of the plane and yellow to the blue portions for contrast. Yarns are spaced on four-inch centers in both directions to give a network of tufts for areas to be tested.





Gearing

. . . how to reduce noise and increase efficiency with modified tooth forms

By Kenneth N. Mills
Assistant Chief Mechanical Engineer
Emsco Derrick & Equipment Co.
Houston, Tex.

HIGH efficiency and low operating-noise level of modern gearing, *Fig.* 1, is the result of increased generating accuracy, and increased knowledge and application of the principles responsible for quiet gear operation. These principles cover the design of gear teeth, shafts and gear housings and, if the optimum results are to be obtained, each of these factors must be given minute attention.

In the case of bevel, spur and single helical gears some of the adverse effects of housing and shaft deflection have been eliminated by introducing a slight curve into the tooth profile in the longitudinal plane as shown in *Fig.* 2. As this type of tooth profile modification tends to concentrate the tooth load in the center of the tooth, it decreases the possibility of the tooth load being concentrated on the ends of the teeth in the event of excessive housing or shaft deflection. However, as it limits the tooth bearing area, it increases the tooth contact stresses beyond the stress level which would exist if ideal contact conditions were maintained.

Because the surface durability of gear teeth is a function of the magnitude of the subsurface contact stresses, "crowning" the tooth face causes a reduction in the theoretical load capacity of the gear train. If the shafts, housing and gears were absolutely rigid, this theoretical loss in capacity would be real. These elements are not always rigid and deflections always exist. For these reasons crowning of gear teeth may result in lower actual contact stresses because the degree of stress concentration due to deflection may exceed that induced by the crowned-tooth profile.

All modern high-efficiency gear trains use the involute gear tooth because it has certain advantages not found in other systems. It has the advantage of being easier to generate accurately and affords a higher degree of flexibility. It can be generated directly from a straight-sided rack or from cutting tools generated from the rack profile. The teeth can be generated at one pressure angle and operated at another pressure angle. Within certain limits, cutters for one pressure angle can be used to generate gears to operate on another pressure angle. The flexibility of the involute system of gearing can best be visualized by examining its basic principles.

The gear-tooth profile is described by the end of a generating line rolling on the base circle, and it can be visualized as a curve traced by unwinding a string from the circumference of the base circle. As the involute is generated from the base circle, it cannot

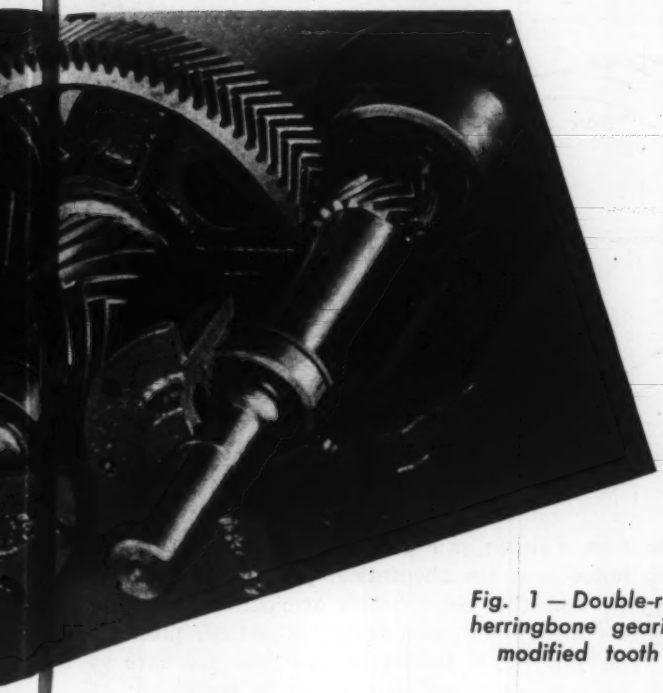


Fig. 1 — Double-reduction herringbone gearing with modified tooth form

extend below this circle. If any portion of the tooth profile extends below the base circle, that portion of the tooth profile will be inactive and must be generated on an assumed profile. This portion of the tooth profile will be undercut as shown in *Fig.* 3, causing a reduction in the tooth beam strength.

Action of a mating pair of involute gears can be compared to that which would occur if two pulleys with diameters corresponding to the base circle diameters were connected with an endless crossed belt as shown in *Fig.* 4. In this example, the straight sections of the belts represent the lines of action for both directions of rotation. The point at which they cross represents the pitch point or the point at which the pitch circles are tangent. This example illustrates one of the distinctive characteristics of the involute system of gearing, which is its flexibility in center spacing.

In this example it is obvious that, if the center distance is altered, the obliquity of the straight portions of the crossed belts with the line of centers would change. Also the location of the intersection of the crossed belts and the line of centers would shift. However, the speed ratio of the assembly would remain constant. Similarly, the center distance of a pair of engaging involutes can be varied within certain limits without altering their speed ratio. When this change is made in a pair of generated involute gears, the pressure angle and running pitch diameters are modified, as the diameter of the base circle is unaltered.

Due to the flexibility of the generated involute system of gearing, it is possible to alter the outside diameters of engaging gears to eliminate undesirable features such as undercut and to obtain more advantageous tooth action. In speed-reduction drives, this is usually accomplished by increasing the outside diameter of the pinion and decreasing the outside diameter of the gear. Gears thus proportioned are cut to standard depths and operate on standard centers. Because the addendum on the pinion is larger than the standard addendum and the addendum on the gear is shorter than the standard addendum, this is called the long and short addendum system of gearing.

A comparison of the tooth action obtained with an undercut pinion and a gear train with long and short addendum teeth is shown in *Fig.* 5. In this illustration, the pinion tooth strength has been increased as the thickness of the tooth at its base has been increased. Also, the length of the active portion of the line of action has been increased. There-

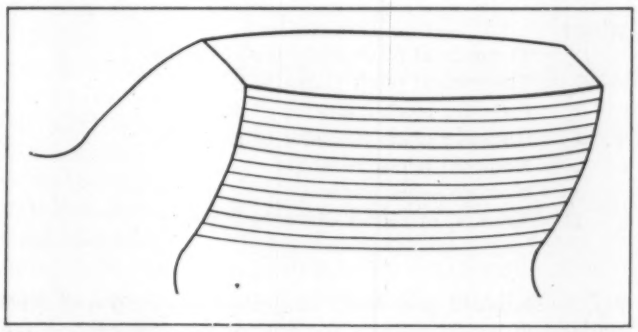


Fig. 2—Above—Slight curve on tooth profile distributes loading resulting from deflection in system

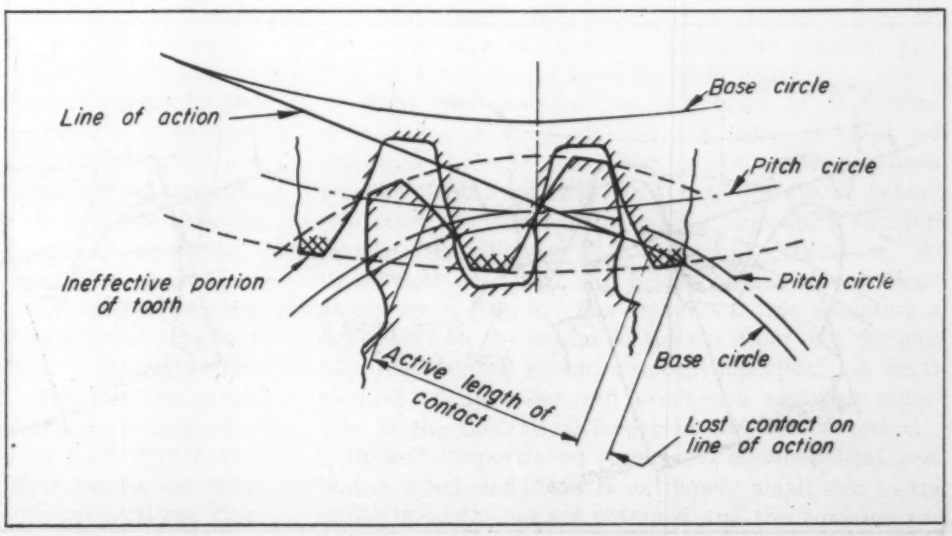


Fig. 3 — Right — Undercut of tooth form to provide clearance reduces its strength

fore, the number of teeth in contact has been increased. This increase in the number of teeth in contact reduces the load carried by each tooth and reduces the noise level of the gear train.

In the case of the long and short addendum gear train, it will be noted that the lengths of the arc of approach and recession are not equal and the arc of approach has been materially shortened. This change in the length of the arc of approach decreases the possibility of the tips of the driven teeth digging into the flanks of the driver teeth under heavy loads and scraping the oil film away in front of the contacting teeth. During recession, the tips of the driver teeth have a wiping action which is conducive to smooth action and good lubrication.

That portion of the involute adjacent to the base circle is difficult to generate accurately; therefore the accuracy of the pinion teeth is increased because they are further removed from the base circle. Also the specific sliding between the teeth is reduced, because it is very high on that portion of the involute near the base circle and reaches infinity there.

Involute gears can be designed for operation on center distances greater than their theoretical centers. This result can be achieved by any one of the following three methods:

1. Enlarging the outside diameters of both the driver and driven elements
2. Enlarging the outside diameter of the driver and using a standard driven element
3. Enlarging the outside diameter of the driven and using a standard driver element.

Gears used in spread-center applications can be produced with standard cutters, if they are cut by the generating process and the teeth are cut to standard depth on enlarged blanks. When the enlarged gears are generated, their base circle diameters are not altered, because they are fixed by the base circle diameter of the generator cutter. However, the pressure angle is altered because the center spacing between the cutter and the cut element is changed and the pressure angle is a function of the angle between the common tangent to the two base circles and the line of centers.

A layout of a pair of gears designed to operate on

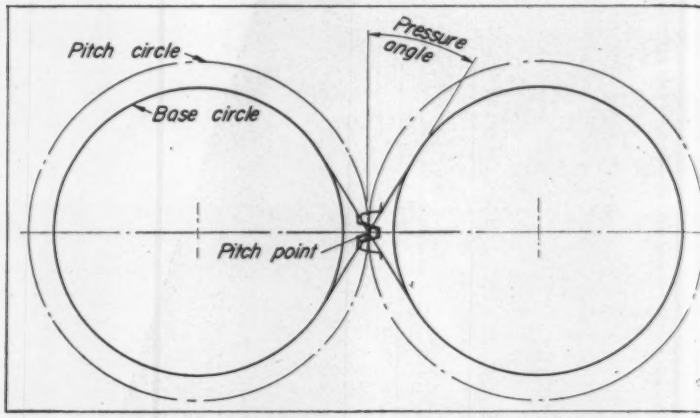


Fig. 4—Action of mating pair of gears may be compared to belts around base circles

spread centers is shown in *Fig.* 6. In this illustration, it will be noted that the theoretical pitch circles are not tangent, and the gears mesh at running pitch circles which are larger than their theoretical pitch circles. The new pitch diameters and new pressure angle can be calculated with the following formulas:

$$d_p = D_p\left(1 + \frac{2E}{D_p + D_g}\right)$$

$$d_g = D_g\left(1 + \frac{2E}{D_p + D_g}\right)$$

$$\cos \phi_1 = \frac{\cos \phi}{1 + \frac{2E}{D_p + D_g}}$$

where

D_p = Theoretical pitch diameter of pinion
D_g = Theoretical pitch diameter of gear
d_p = Running pitch diameter of pinion
d_g = Running pitch diameter of gear
ϕ = Nominal pressure angle
ϕ_1 = New pressure angle
E = Amount of center distance increase

Fig. 5—Standard gear teeth compared with long and short addendum modifications, increasing the strength of the pinion. Modified gear is shown at right

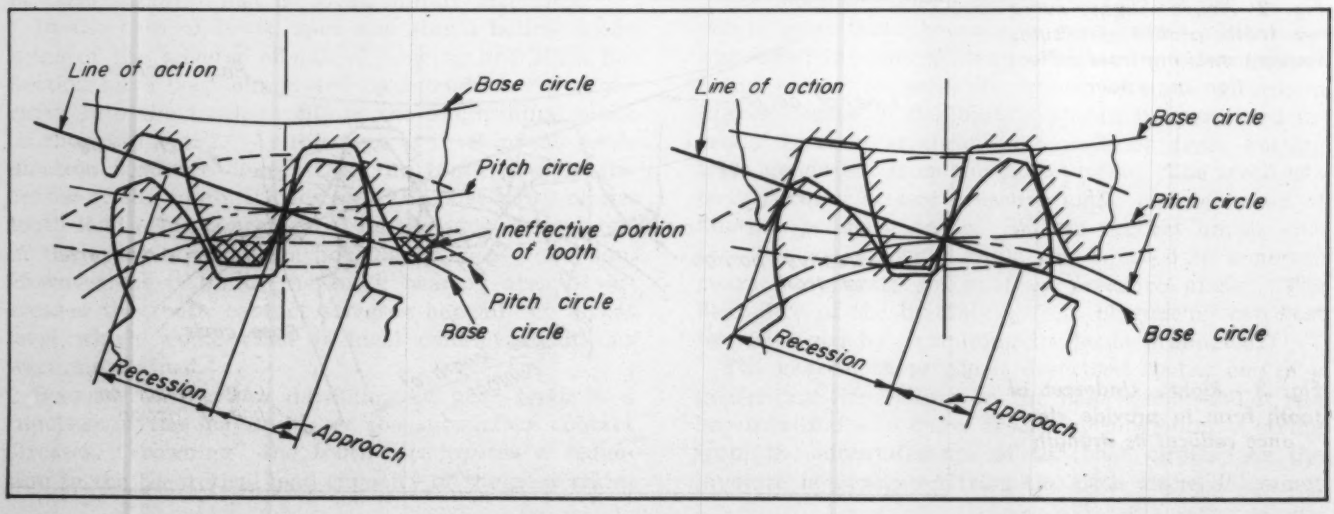


Fig. 6—Right—Layout of gears designed to operate on spread centers

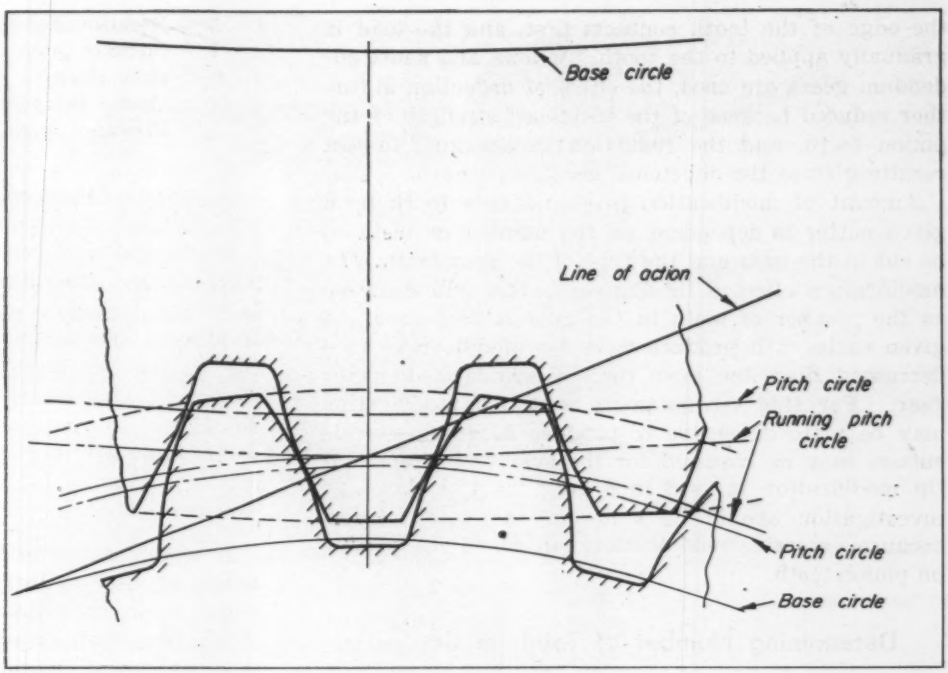
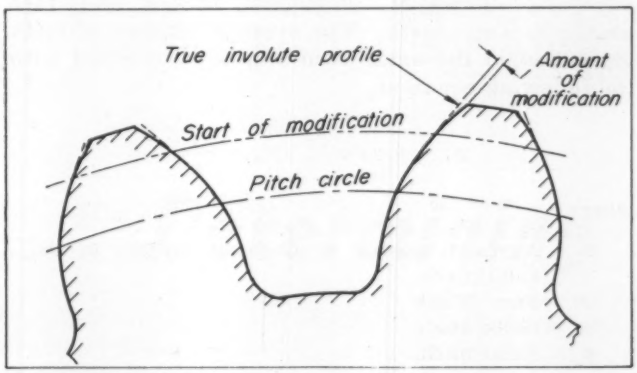


Fig. 7 — Below — Relief on tooth tip reduces effect of errors in tooth spacing and profile



When designing gears for operation on spread centers, the width of the tooth tip should be checked on both elements. The minimum tooth tip width should not be less than 10 per cent of the tip width of a standard tooth.

Enlarging both the driver and driven elements to produce gears for use on increased centers should be used, if the drive is reversing. It may be used on nonreversing drives when the pinion is not undercut and the pinion tooth strength is satisfactory. In this system, the relative enlargements should be proportioned so the lengths of approach and recession are equal. This result can be achieved by making the distance from the running pitch circle to the outside diameter of the gear blank equal on both elements.

The system of enlarging the driver and using a standard driven is preferable for speed-reducing drives as it retains all of the advantages of long and short addendum gearing. However, it should not be used for speed-increasing drives. This practice is advantageous when three or more gears are in mesh and the intermediate gear functions as both driver and driven. In this case, the third gear can be cut with standard outside diameter and tooth proportions. This will maintain the maximum length of line of action.

Using an enlarged driven and a standard driver should only be employed to eliminate undercut. When used to eliminate undercut it does not adversely affect the length of the line of action, the undercut portion of the tooth being inactive. However, because undercut decreases tooth strength, a stronger tooth and improved tooth action will be obtained.

Sources of Noise

Noise level of a gear train is a function of the accuracy of tooth spacing and profile as well as tooth deflection and number of teeth in contact. The adverse effects of spacing and profile errors can be partially nullified by introducing a slight amount of relief to the tip of the tooth as shown in *Fig. 7*. The effect of this tip relief is to permit the driven gear to lag slightly and thus pick up any errors gradually. This decreases the possibility of the driven teeth digging into the flanks of the driver teeth, and scraping the oil film from these teeth. If relief is applied to the driven teeth only it will prevent interference between the tips of these teeth and the sensitive portion of the involute near the base circle.

While this practice has a number of theoretical advantages in spur gearing, the value of these advantages in single and double helical gearing is questionable. Because that portion of the tooth beyond the start of modification is cut below the involute profile, theoretically it is inactive. Therefore, the theoretical length of the line of action is decreased as shown in *Fig. 8*. The amount of this reduction is dependent on the extent of the tip relief and the contact lengthening effect of tooth deflection. A small amount of tip relief will produce a material reduction in the theoretical length of the line of action.

In well proportioned single and double-helical gear trains, tooth deflection is extremely small due to the multiple tooth contact obtained and the common use of the stub tooth form. Also, in this type gearing,

the edge of the tooth contacts first, and the load is gradually applied to the tooth. If long and short addendum gears are used, the effect of deflection is further reduced because of the increased strength of the pinion teeth, and the reduction in engaging impact resulting from the shortened arc of approach.

Amount of modification produced in a tooth by a given cutter is dependent on the number of teeth to be cut in the gear and the type of the gear teeth. The modification effected by a given cutter will decrease as the number of teeth in the gear is decreased. A given cutter will produce more tip modification on a decreased diameter gear than a standard diameter gear. For this reason gears with tip modification may be more expensive to produce because separate cutters may be required for the gear and pinion. If tip modification is used in a gear train, a thorough investigation should be made of the tooth action, because excessive modification can cause tip bearing on pinion teeth.

Determining Number of Teeth in Contact

One of the major factors influencing the quietness of a gear train is the number of teeth in contact and the variation in total length of tooth contact in single and double-helical gear trains. In a spur gear train the number of teeth in contact should be 1.4 minimum. The number of teeth in contact in the plane of rotation can be determined by the following equations:

$$L_a = \frac{\sqrt{d_o^2 - D_p^2 \cos^2\phi} + \sqrt{D_o^2 - D_g^2 \cos^2\phi}}{2} - C \sin\phi$$

$$p_b = p \cos\phi \quad ; \quad N = \frac{L_a}{p_b}$$

where

L_a = Length of line of action
d_o = Outside diameter pinion
D_o = Outside diameter gear
D_p = Pitch diameter pinion
D_g = Pitch diameter gear
N = Number of teeth in contact in plane of rotation
P = Circular pitch
P_b = Base pitch
C = Center Distance
ϕ = Pressure Angle

Effect of Elastic Distortion

While the basic characteristics of helical gearing promote smooth tooth action, elastic distortion of the teeth can introduce slight variations in tooth action. If it were practical to design all gear trains so that the number of teeth in the plane of rotation was slightly greater than an integral number, this effect would be materially reduced. However, this is not always practical, but helical gear trains can be designed so the variation in total length of tooth contact is a minimum.

If a gear train is designed to assure the maintenance of this condition, the adverse effect of these small tooth deflections will be kept at a minimum. While the result cannot be achieved in all gear trains without using special cutters having nonstandard pressure angles, it can be achieved or approached by adjusting diameters, diametral pitches and face widths in some cases. The average number of teeth in contact in the axial plane can be determined with the following equation.

$$p_x = p \cot\psi \quad ; \quad N_a = \frac{F}{p_x}$$

where

N_a = Average number of teeth in contact in the axial plane
F = Face Width
ψ = Helix angle
p_x = Axial pitch

If the average number of teeth in contact in the axial plane is slightly greater than an integral number, there will be no variation in the length of tooth contact. If a gear train is designed to meet either of these conditions the resultant gear train will have a very low operating noise level.

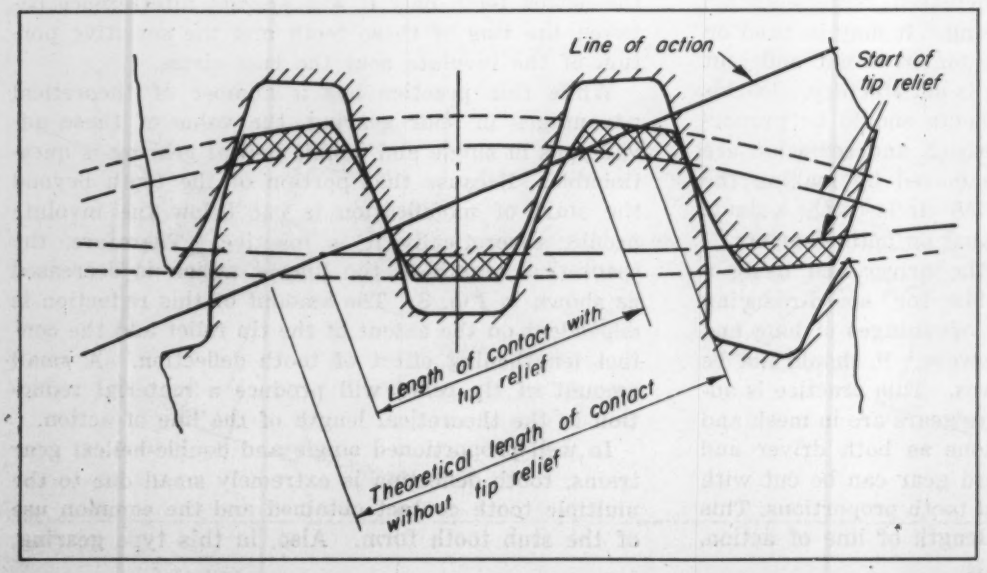


Fig. 8—Effect of tip relief on reducing the length of the line of action

Photo by Austin W. Huesgen

Determining Recoil Loading

By Macon Fry
Ordnance Consultant
Harrington Park, N. J.

IN THE past it has been customary to design the structures of rigidly mounted machine-gun turrets to withstand arbitrarily chosen loads supposed to represent the recoil forces. However, even if the peak total gas pressure on the breech of a gun is used for this figure, one cannot be certain that a given structure will be safe under conditions of repetitive fire, since the structure is a dynamical system receiving periodically timed impulses and therefore may exhibit resonance phenomena. When the M45 multiple machine-gun mount, which had been entirely satisfactory with 0.50-cal. guns (*Fig.* 1), was first adapted to 20-mm guns, failures occurred which showed the need for more exhaustive study of this problem, taking into account factors previously overlooked.

Recoil momentum of a gun is developed so suddenly that it is practically an impact. It is as if a definite amount of momentum were given to the mount in a single blow at each shot. While it is true that the elasticity of the

Fig. 1—Top—Structure of machine-gun turret such as this M45 quadruple 0.50 caliber mount is a dynamical system, loading of which requires careful analysis

USE OF an arbitrary figure for recoil force in machine-gun turret design is dangerous because, under conditions of repetitive fire a turret may exhibit resonance phenomena. A method is developed for determining the recoil force, based upon the natural period of vibration of the turret, the cyclic rate of fire, and the momentum of the issuing bullet and powder gases

mount starts to absorb momentum as soon as the bullet commences to move, the inertia of the recoiling parts is usually so great that very little is absorbed before the bullet is out of the barrel. In recoil-operated guns a small amount of momentum is absorbed by the recoil spring, but it is on the conservative side to regard the recoil momentum as being delivered up instantaneously in all cases, and as having a value equal to that of the issuing bullet and powder gases. This proceeds from the principle of conservation of momentum (Newton's Second Law).

Gun mounts are, of course, physical structures having "distributed" constants; that is, mass and elasticity are distributed throughout. However, it is usually true that the greater part of the mass is concentrated in a region of high rigidity, while the more elastic parts of the system have relatively slight mass. Thus it is possible, with little error, to simplify the problem to a single degree of freedom by considering the constants as "lumped" (*Fig.* 2), wherein a single rigid mass recoils against a weightless spring.

The mount may deflect under recoil in several ways, such as rotation as a result of "wind-up" of azimuth or elevation shafting, or bending of the structure as a whole. An attempt is usually made to dispose the guns equally above and below the elevation axis, and to either side of the azimuth axis, so that no net torsional moments are exerted on the shafting *as long as the guns fire in synchronism.* However, there is aways the possibility of misfire, even in synchronized systems, so the structure must be designed to accommodate the worst conditions of unbalance.

Regardless of the mode of deflection, it will be shown in the Appendix that the maximum force due to recoil may be represented by the equation:

$$F = \pi \frac{U}{T_1} \csc\left(\frac{T_2}{T_1 \pi}\right) \quad \text{.....(a)}$$

The quantities must, of course, be in consistent units, such as F in pounds, U in pound-seconds, T_1 and T_2 in seconds.

Note that Equation *a* gives the maximum force *per gun* if U represents the recoil momentum of *one* projectile and its gases. The following equation[1] determines this quantity:

$$U = (M_P + \tfrac{1}{2} M_G)\, V_P \quad \text{.....(b)}$$

all quantities being likewise in consistent units.

Equation *a* should be applied for all the conditions of deflection which might occur, as mentioned in an earlier paragraph (all guns firing in synchronism; one or more guns misfiring, etc.). Note that the natural period of vibration may be different for the different modes of deflection. All must be examined in order to determine the worst case. Likewise the effect of variations in the cyclic rate (if any) should be examined.

From Equation *a* it is evident that the least force is exerted when $T_2 = \frac{1}{2}\, n\, T_1$ (n being any *odd* integer); that is, when the period between successive shots is any *odd* multiple of one-half the natural period of vibration of the system. Conversely, the worst possible case is when n is an *even* integer, or the period between successive shots equal to a multiple of the natural period. Note that an infinite number of resonances will exist at exciting periods longer than the natural period of the system[2]. Consequently, as T_2 in Equation *a* is lengthened, F will approach infinity again and again. (Obviously some part of the structure must fail before a resonant point is quite reached).

PENDULUM ANALOGY: A qualitative demonstration of the foregoing can be produced by the experiment illustrated in *Fig.* 3, in which a pendulum is struck with a hammer at periodic intervals.

If the pendulum is struck always in the *middle* of a swing, as at (*a*), blows must be applied at intervals equal to one-half the natural period of vibration (or some *odd* multiple of one-half), and the swings will never go higher than that produced by a single blow. On the other hand, if the pendulum is to be struck only at the *end* of a swing, as at (*b*), blows must be applied at intervals equal to the natural period of vibration (or some multiple thereof), and the swings will build up to ever-larger values.

Nomenclature

A = Amplitude of vibration
C = Phase angle with respect to time reference axis
F = Force exerted on mount
K = Spring constant
M = Mass of recoiling parts
M_P = Mass of projectile
M_G = Mass of powder gases
T_1 = Natural period of system $= 2\pi\sqrt{M/K}$
T_2 = Interval between successive shots
U = Momentum per shot
V_P = Muzzle velocity of projectile
x = Deflection of mass
t = Chronological time

[1] *Thermodynamics of Firearms*, Page 97, 1943, McGraw-Hill.

[2] Or, looked at from the Fourier concept, impulse excitation may be said to contain all harmonics of the fundamental frequency. This is the point of view taken by electronic engineers in connection with their "square wave" generators.

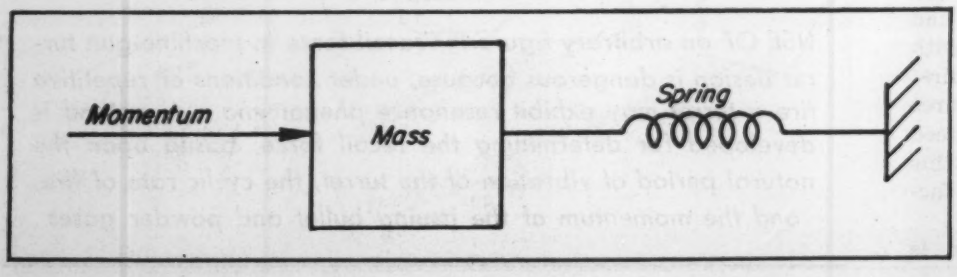


Fig. 2 — Problem of mount deflection is simplified by considering constants as "lumped" in a single rigid mass which recoils against a weightless spring

PRACTICAL EXAMPLE: An experimental quadruple 20-mm mount had the following characteristics: Natural frequency of vibration: 1300 cycles per minute (or $T_1 = 60/1300$ sec). Cyclic rate of fire: 750 to 850 rounds per minute per gun (or $T_2 = 60/750$ to $60/850$ sec). Recoil momentum per shot: 35 pound-seconds.

It is desired to know the maximum recoil force exerted on the mount in order to determine whether any parts of the structure will be overstressed.

Using the lower limit of cyclic rate and substituting in Formula (a):

$$F = 35\,\pi\,\frac{1300}{60}\,\csc\left(\frac{1300}{60}\cdot\frac{60}{750}\,\pi\right)$$

$$= 3200 \text{ pounds (per gun)}$$

With the upper limit of cyclic rate:

$$F = 35\,\pi\,\frac{1300}{60}\,\csc\left(\frac{1300}{60}\cdot\frac{60}{850}\,\pi\right)$$

$$= 2400 \text{ pounds (per gun)}$$

Thus the greatest recoil force to be expected within this range of cyclic rates is 3200 pounds per gun at the lower limit. It would be important to specify that the cyclic rate under no circumstances fall below the above lower limit; if it were to fall merely to 650 rounds per minute a condition of resonance would occur and the mount would be endangered.

DAMPING: No account has been taken of possible damping in the development of Equation *a* in the Appendix, i.e., perfect resilience has been assumed. In the system here considered what slight damping exists will be due chiefly to mechanical hysteresis in the metal making up the structure, and will be incommensurable at practical values of stress. It would have a ponderable effect only in the close proximity of resonant points and then would be merely of academic interest, since the loading would become excessive in most cases before such a point could be approached. In other words, it is taken for granted that the structure will not be designed for stresses beyond the proportional limit!

Of course it would be possible to build a recoil absorber containing a large amount of viscous or other damping, for insertion between the gun and the mount, but such a device would be beyond the scope of this article, which deals only with rigidly mounted guns. Incidentally, it might be remarked that certain so-called "adapters" used with some machine-gun turrets appear to exert very little damping effect; it is probable that their principal function is to alter the natural period of the turret so as to avoid a resonant point.

Appendix

DERIVATION OF EQUATION *a*: The unconstrained vibration of the mass can be represented by:

$$x = A \sin\left(\frac{2\pi t}{T_1} + C\right) \quad \ldots\ldots(1)$$

and

$$\frac{dx}{dt} = \frac{2\pi}{T_1}\,A \cos\left(\frac{2\pi t}{T_1} + C\right) \quad \ldots\ldots(2)$$

where constant C represents the *phase angle* of the vibrating mass at the instant an impulse is received, which is taken as the zero time reference point. As will become apparent shortly, the actual value of this constant is dependent upon the ratio of T_2 to T_1.

When the system is being excited by the gun, the steady state must be such that both the *position* and the *velocity* of the mass immediately after receiving one impulse are identical with those quantities immediately following the next. Applying the first requirement to Equation 1:

at $t = O$: $\quad x = A \sin C$

at $t = T_2$: $\quad x = A \sin\left(\frac{2\pi T_2}{T_1} + C\right)$

and

$$A \sin C = A \sin\left(\frac{2\pi T_2}{T_1} + C\right) \quad \ldots\ldots(3)$$

or

$$\sin\left(\frac{2\pi T_2}{T_1} + C\right) - \sin C = O$$

$$2 \sin\left(\frac{\pi T_2}{T_1}\right) \cos\left(\frac{\pi T_2}{T_1} + C\right) = O$$

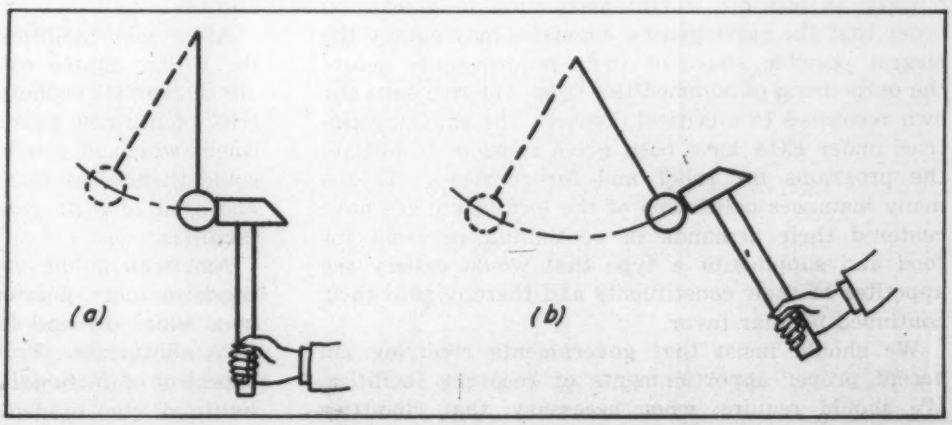


Fig. 3—Pendulum analogy illustrates how blows struck at midpoint of vibration period (left) do not increase vibration magnitude, whereas blows struck synchronously with vibration period (right) build up magnitude of vibration to ever-larger values

whence

$$\cos\left(\frac{\pi T_2}{T_1} + C\right) = O \quad \ldots\ldots (4)$$

and

$$\sin\left(\frac{\pi T_2}{T_1} + C\right) = 1 \quad \ldots\ldots (5)$$

Applying the second requirement to Equation 2:

$$\text{at } t = O: \frac{dx}{dt} = \frac{2\pi}{T_1} A \cos C$$

At $t = T_2$ the mass has just received an impulse augmenting the velocity by an amount U/M, therefore:

$$\frac{dx}{dt} = \frac{2\pi}{T_1} A \cos\left(\frac{2\pi T_2}{T_1} + C\right) + \frac{U}{M}$$

and

$$\frac{2\pi}{T_1} A \cos C = \frac{2\pi}{T_1} A \cos\left(\frac{2\pi T_2}{T_1} + C\right) + \frac{U}{M} \quad \ldots\ldots (6)$$

or

$$\frac{4\pi}{T_1} A \sin\left(\frac{\pi T_2}{T_1}\right) \sin\left(\frac{\pi T_2}{T_1} + C\right) = \frac{U}{M} \quad \ldots\ldots (7)$$

From Equation 5,

$$\sin\left(\frac{\pi T_2}{T_1} + C\right) = 1$$

therefore Equation 7 becomes:

$$\frac{4\pi}{T_1} A \sin\left(\frac{\pi T_2}{T_1}\right) = \frac{U}{M}$$

or

$$A = \frac{T_1 U}{4\pi M} \csc\left(\frac{\pi T_2}{T_1}\right) \quad \ldots\ldots (8)$$

Since the force exerted on the structure must be equal to the product of the deflection and the spring constant, or Kx, the greatest such force is evidently KA, hence:

$$F_{max} = \frac{K T_1 U}{4\pi M} \csc\left(\frac{\pi T_2}{T_1}\right) \quad \ldots\ldots (9)$$

since

$$\frac{K}{M} = \left(\frac{2\pi}{T_1}\right)^2$$

$$F_{max} = \frac{\pi U}{T_1} \csc\left(\frac{\pi T_2}{T_1}\right) \quad \ldots\ldots (10)$$

Equation 10 is the expression given earlier as Equation *a*.

Europe's Need for Production Facilities

ECA Administrator, Paul G. Hoffman, has repeatedly emphasized that the European Recovery Program means exactly what its name implies. The great need of Europe is for the production of goods; and adequate production can be obtained only by the use of facilities such as machine tools. Continued delays, therefore, in the shipment of production machinery, occasioned by the pressure of the recipient nations that ECA dollars be used largely for goods that satisfy appetites, are slowing the progress toward real recovery.

An urgent need of the program is to stimulate, as quickly as possible, actual production in Europe in order that the participating countries may supply the largest possible share of their requirements before the outpouring of commodities from America saps our own resources to a critical degree. The sixteen countries under ECA have been given freedom to initiate the programs for relief and for recovery. In too many instances politicians of the local countries have centered their demands in continuing requests for food and supplies of a type that would satisfy the appetites of their constituents and thereby gain their continued popular favor.

We should insist that governments receiving aid accept proper apportionments of recovery facilities. We should require, when necessary, that countries being helped also accept our guidance in the allocation of funds. To advance aid without a corresponding degree of control is inefficient and unwise. Many of the political and financial difficulties in Europe will have been removed or relieved with a stimulation of production. Mechanization of agriculture will have important effects on food supplies.

Europe needs better equipment for steel production and fabrication, for the manufacture of trucks and farm machinery, for production of mining machinery and countless items which are in short supply in the United States but are desperately needed abroad.

All of such facilities cannot be shipped abroad from the United States without putting a great strain on our industrial economy. There are, however, industrial plants now existent in England and on the continent which, if provided with modern machine tools, could themselves manufacture, using their own labor and some of their own material, many of these needed facilities.

American public opinion should urge that our authorities more pointedly direct the needy countries in a wider demand for production facilities in their ECA allotments. *From a statement by A. G. Bryant, president of National Machine Tool Builders' Association.*

Superprecision Ball Bearings

By Thomas E. Rounds
Chief Engineer
The Barden Corp.
Danbury, Conn.

Part III—Selection for Low Friction, Rigidity and Load Capacity

IN SELECTING conventional types of bearings for applications such as gyroscopic gymbals, pivots and all locations requiring low friction at very low speeds, a number of factors should be considered and kept in mind.

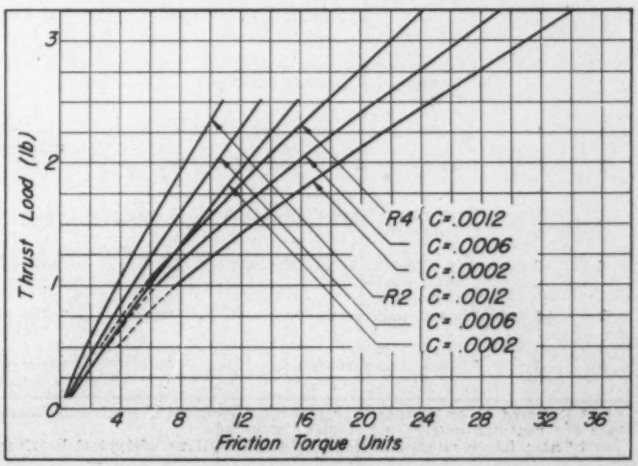
SELECTION FOR LOW FRICTION: First, friction increases under the following conditions:

1. Roughly in proportion to the pitch diameter of the bearing
2. With the degree of conformity of balls and raceways
3. With the closeness of internal fitting
4. With the load
5. With misalignment, improper fitting and geometrical errors within the bearings
6. With the weight of the ball retainer and the extent of its contact with the balls and inner and outer rings
7. With the quantity or viscosity of the lubricant
8. With the quantity and size of solid foreign particles present in the bearings.

Second, friction diminishes in the presence of mild vibration, provided damage to the balls and raceways, known as "contact or fretting corrosion," is avoided.

In speaking of friction, a careful distinction should be made between running frictional torque and static or breakaway torque. Running friction is generally lower than the breakaway friction and is usually not considered on applications where only small angular movements are involved, as on gyroscopic gymbals, pivots and the like. Again, a condition entirely distinct from the above, which is present at times is known as "wind-up". Developing as a wedging action between the balls and the retainer, this condition results in higher and higher friction as rotation is continued in the same direction and

Fig. 12—Curves showing relationship between applied thrust load and breakaway friction for different values of diametral clearance with R-2 (bore 0.125-inch, OD 0.375-inch and width 0.1563-inch) and R-4 (bore 0.250-inch, OD 0.625-inch and width 0.1969-inch) bearings



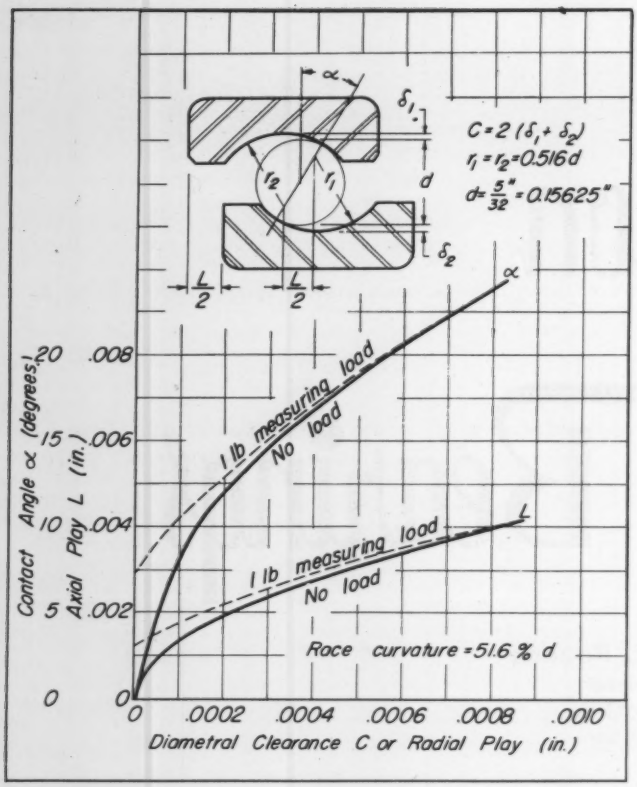

C = 2 (δ1 + δ2)
r1 = r2 = 0.516 d
d = 5/32 = 0.15625"
Contact Angle α (degrees)
Axial Play L (in.)
1 lb measuring load
No load
1 lb measuring load
No load
Race curvature = 51.6 % d
Diametral Clearance C or Radial Play (in.)

Fig. 13—Curves showing relationship between contact angle and axial play versus diametral clearance for a typical deep-groove or angular-contact bearing with 7 balls of 5/32-inch diameter

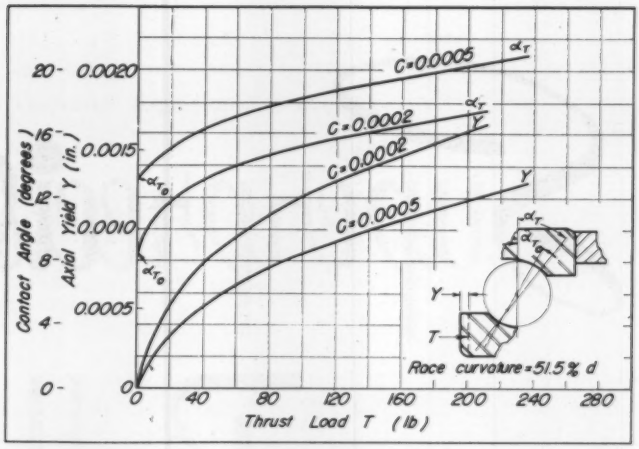


Fig. 14—Curves showing relationship between contact angle and axial yield versus thrust load for different values of diametral clearance for an angular-contact bearing with 13 balls of 5/16-inch diameter

can only be eliminated by a violent increase in the rotative torque resulting in slippage, or by reversing the direction of rotation to release the wedging forces. This condition, however, is present to only a minor degree in bearings with correct retainer design and in the manufacture of which there has been proper control of manufacturing errors. It is seldom present to any great degree where misalignment is low.

Proper selection of bearings for low friction, therefore, involves consideration of the following bearing characteristics:

1. Smallest size available considering factors of static load capacity
2. Curvature radii of raceway somewhat greater than the usual standard for general-purpose bearings
3. Maximum internal clearance
4. Lightweight metallic retainers having minimum contact with the bearing elements.

Where low friction is the paramount requirement the trend is toward the use of the smallest possible bearing. Shown in *Fig.* 12 are curves which indicate

TABLE IV—Bearing Selection Guide For Superprecision Bearings

Type	Fig.†	Basic Classification	Relative Capacity* Pure Radial Load	Relative Capacity* Pure Thrust Load	Precision Grade Available ABEC-5	Precision Grade Available ABEC-7	Duplex Arrangements Available	High-Speed Composition Retainers Available	Low-Friction Characteristics Available
1	1a 1b	Deep-groove, single-row Deep-groove, single-row, shielded	1.0	0.6–1.1	yes	yes	DB,DF	yes	yes
2	2	Angular contact, single-row, low-angle	1.0–1.3	1.3–2.0	yes	yes	DB,DF,DT	yes	yes
	2	Angular-contact, single-row, high-angle	0.8–1.1	2.0–3.3	yes	...	DB,DF,DT	yes	...
3	3	Angular-contact, single-row, low-angle, separable outer ring	0.8–1.2	0.6–1.2	yes	yes	DB,DF,DT	yes	yes
4	4	Loading groove, single-row	1.2–1.4	not recommended	...	...	.....	...	...
5	5a	Deep-groove, double-row, radial	1.8–1.9	1.2–1.5	yes	...	.....	...	...
	5b 5c	Deep-groove, angular-contact, double-row	1.7–1.8	1.8–3.0	yes	...	.....	...	...
6	6	Self aligning, spherical outer ring, double-row	0.8–1.1	0.15–0.4	yes	...	.....	yes	yes
7	7	Thrust, single-direction	none	varies with series	...	...	.....	...	...
8	8	Thrust, two-direction	none	varies with series	...	...	.....	...	...

* Referred to or compared to that of deep-groove, single-row bearings. Figures indicate average values for comparable sizes and series of bearings for bearings singly (not duplex) mounted.

† These figure numbers refer to the illustrations of typical bearings shown in Part I of this series in the November issue.

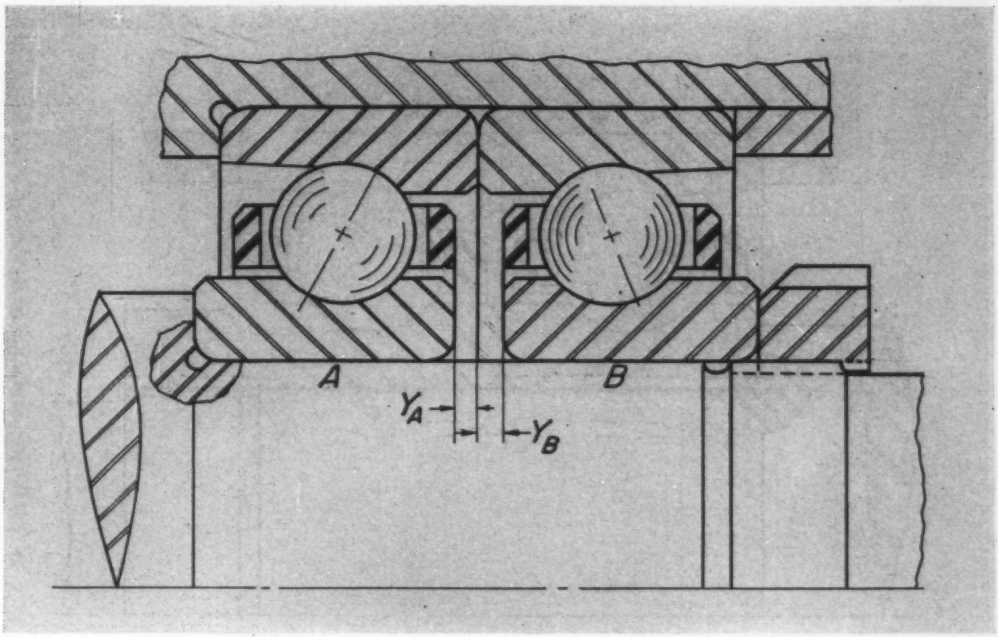


Fig. 15—Duplex pair of bearings shown in back-to-back or DB arrangement with end play only taken up

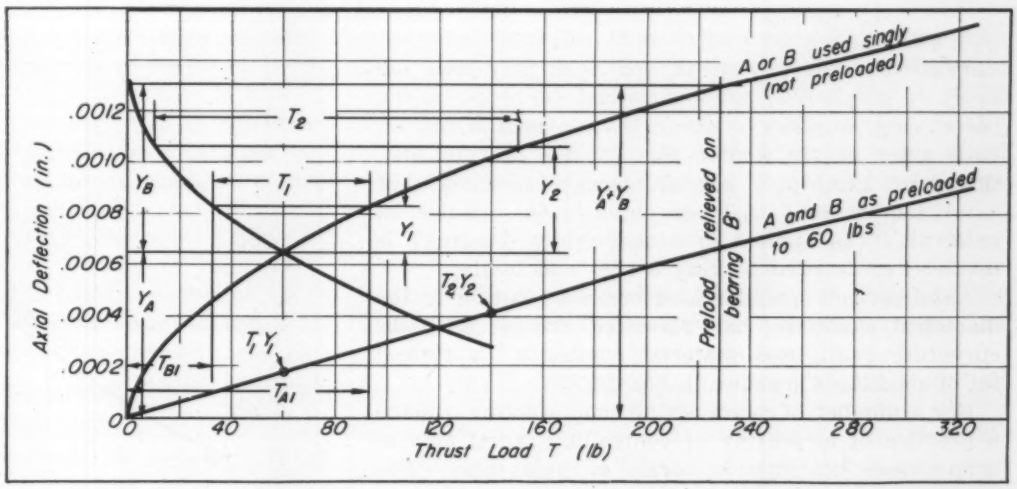


Fig. 16—Curves showing relationship of axial yield versus thrust load for the duplex pair of bearings in Fig. 15

the relationship between end thrust loading and breakaway friction torque for different values of radial play for two typical instrument bearing sizes, R-2 and R-4. It should be noted that running friction torque is less than the torque required for breakaway or starting, the latter being the critical factor of interest in the majority of gyroscopic pivot and indicator type instrument applications. Studies are now being made of the effect of static loading on the frictional characteristics of instrument type ball bearings.

Rigidity Controlled by Angular and Radial Play

SELECTION FOR RIGIDITY: It is frequently necessary on precise applications to control the axis of rotation and the axial position of a shaft or spindle accurately under varying values of external radial and thrust loading. Inherently, most rolling contact bearings operate with a positive internal clearance. The simplest and most generally used bearing type, the single-row, deep-groove, is almost always furnished with a few ten-thousandths diametral clearance to allow for the press fit usually required, to provide for some misalignment, and to provide for temperature gradient between shaft and housing together with a reasonable degree of end thrust capacity. Single-row, angular-contact bearings of the low-angle type are fitted with about the same order of diametral clearance as are single-row, deep-groove bearings. Single-row, high-angle bearings are fitted internally with greater values of diametral clearance. The chart in *Fig.* 13 illustrates the relationship between axial play and radial play for a typical deep-groove or angular-contact bearing.

Axial play of a single-row, deep-groove bearing is defined as the total axial movement of the inner ring in relation to the outer ring under a given measuring load. The theoretical no-load relationships of contact angle, axial play and diametral clearance are given by the solid curves, and the values with a one-pound measuring load are given by the dotted

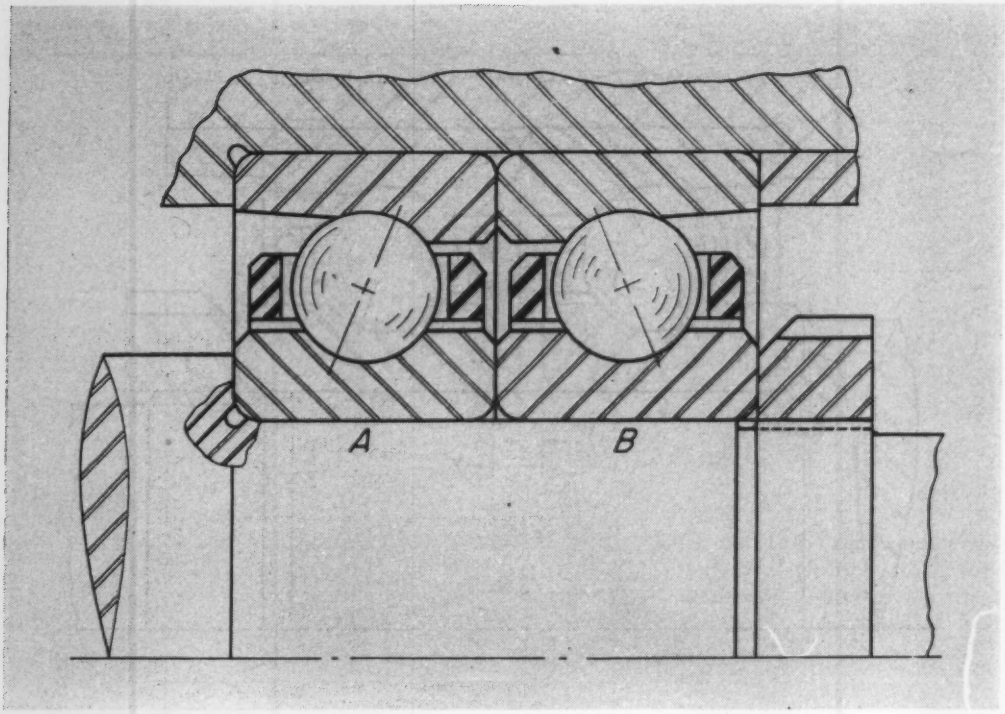


Fig. 17—Bearing arrangement of Fig. 15 shown under full preload with inner rings just touching

Fig. 18—Curves showing relationship between resulting bearing thrust loading and externally applied load for preloaded pairs

curves. The curve, *Fig.* 13, for axial play does not apply to single-row, angular-contact bearings, as the outer ring raceway contour is not continuous on both sides of the center line of the bearing and, therefore, axial play has no definite meaning, but axial displacement, $L/2$, or one-half the theoretical axial play (as applied to a deep-groove bearing) is involved in detailed bearing design and tooling.

Axial deflection under load bears a relation to the diametral clearance, ball diameter, number of balls, curvature radii, and material constants. A typical set of conditions is shown in *Fig.* 14.

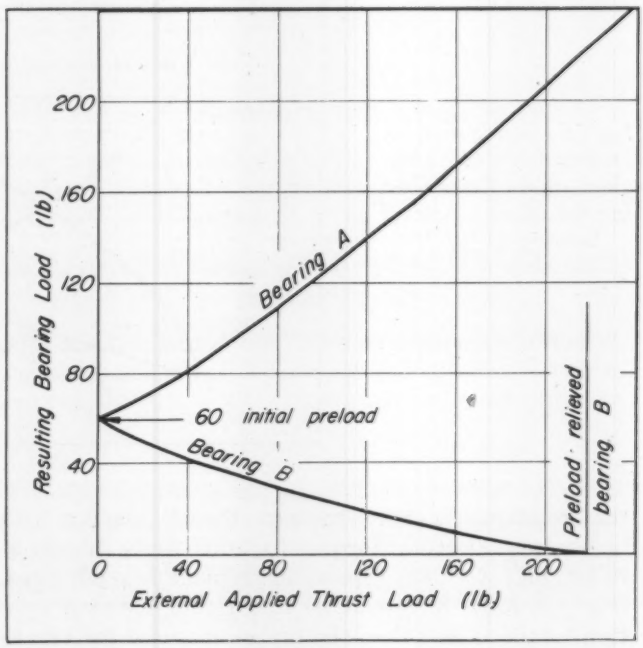
For a number of years certain manufacturers made a practice of measuring or controlling radial play in deep-groove bearings in terms of axial play. For the looser fits, provided groove curvature radii are controlled very accurately in relation to the ball sizes used, axial play measurement may be used with some degree of accuracy to control or segregate radial play ranges. However, the errors become quite serious for small values of radial play.

An examination of the curves in *Fig.* 13 shows that even for a light measuring load of one pound some axial deflection is present in a zero-clearance bearing. When inevitable variations in curvature radius and ball size are considered, rather serious variations in resulting axial play are developed. With heavier gaging loads the errors are greater.

The bearing industry today generally gages radial play directly and the trend is to furnish bearings to radial play specifications only.

Obviously, the looser the bearing is fitted, the less will be the axial deflection or yield under load, since the initial no-load contact angle is higher and the unit ball load is lower.

However, a practical limit with regard to contact angle is soon reached due to limiting depths of grooves and considerations of friction when the bearing is run at high speed. Inherently, untrue rolling action and slippage increase rapidly with the increase of contact angle. Furthermore, high-angle bearings are less rigid radially than low-angle bearings, and in most precise applications radial rigidity is more important than axial rigidity. The majority of precise applications therefore use low-angle bearings.



PRELOADING: At an early date in ball bearing development, the term "preloading" came into being. In its simplest form, bearings were fitted initially tight radially, or in other words, with negative radial clearance. Such bearings obviously have extremely limited thrust capacity and are seriously affected by tight press fits, misalignment and temperature

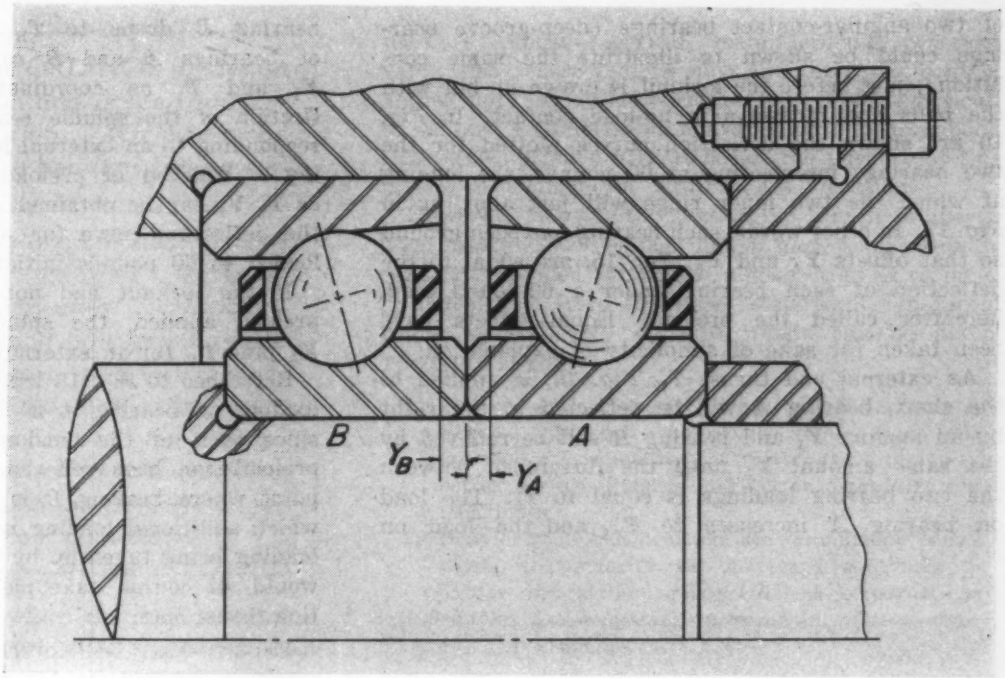


Fig. 19—Duplex pair of bearings shown in face-to-face or DF arrangement with end play only taken up

changes. Also, axial rigidity characteristics are poor.

In another form preloading had reference to the adjustment of opposed bearings by means of shims, threaded collars or spring loading. Use of shims or adjustable threaded collars, while quite satisfactory where accurate control of errors in machining and extent of loading at time of assembly can be assured, generally are found to become less satisfactory as speeds are increased. Spring loading of high-speed bearings is widely used and is highly successful.

BUILT-IN PRELOADS: Succeeding the attempt at radial preloading an ingenious development was the deliberate offsetting of the ring faces of bearings mounted together, thus taking up initial axial play by deliberate elastic deformation of the raceways. This is known as built-in preloading or, in other words, the manufacture of bearings with carefully regulated face offsets on individual bearings. While it is possible for a skilled user to use spacing sleeves of unequal length to accomplish this same purpose it is obviously more desirable for the bearing manufacturer to do this work on the bearings during assembly operations at the bearing plant, where gages of the proper type are available as well as more expert and exact control of the variables involved.

In *Fig.* 15, bearings *A* and *B* illustrate the mounting

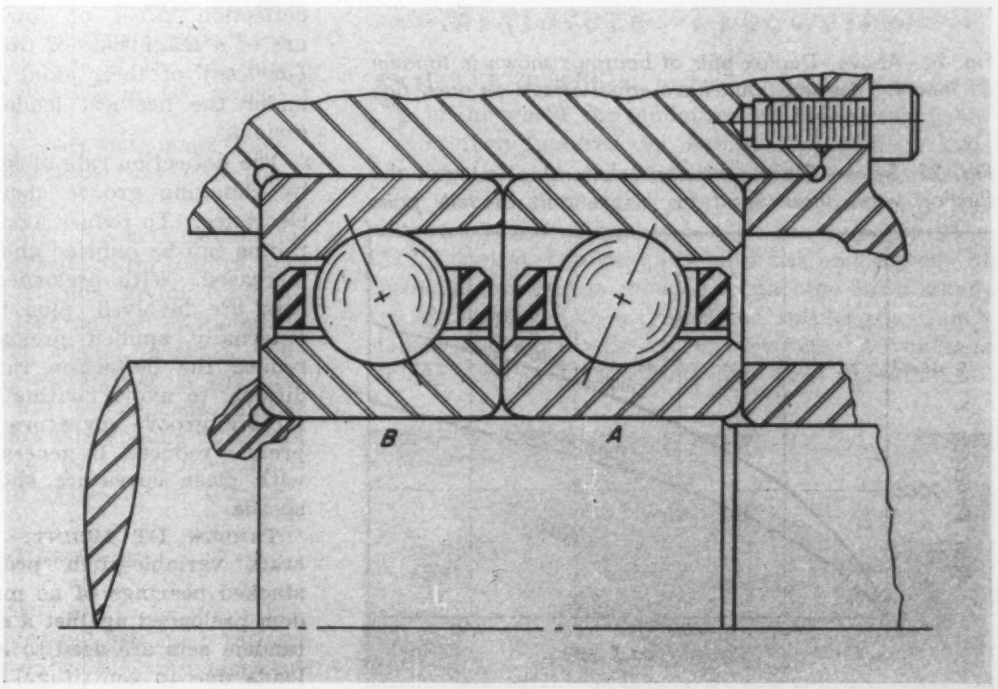


Fig. 20—Bearing arrangement of Fig. 19 shown under full preload with outer rings just touching

of two angular-contact bearings (deep-groove bearings could be shown to illustrate the same condition), just before the locknut is drawn up but with the balls and raceways in no-load contact. In *Fig.* 16 are shown the deflection curves plotted for the two bearings intersecting at 60 pounds, the loading at which the two inner rings will just abut, as in *Fig.* 17. In other words, each bearing has been ground so that offsets Y_A and Y_B, *Fig.* 15, are equal to the deflection of each bearing under a 60-pound load, hereafter called the preload. Equal offsets have been taken for sake of simplicity of explanation.

As external end thrust T_1, *Fig.* 16, is applied to the shaft, bearing *A* will be deflected to the right by an amount Y_1 and bearing *B* will be relieved by the same amount Y_1 until the difference between the two bearing loadings is equal to T_1. The load on bearing *A* increases to T_{A1} and the load on bearing *B* drops to T_{B1}. A point on the plot of bearings *A* and *B* can now be plotted using Y_1 and T_1 as coordinates. Not until the deflection of the spindle reaches a value of Y_B corresponding to an external load of 228 pounds is bearing *B* relieved of preload. Successive points such as T_2 Y_2 can be obtained similarly to allow plotting the deflection curve for *A* and *B* together as preloaded to 60 pounds initially.

If the locknut had not been drawn up, i.e., no preload applied, the spindle would have deflected Y_A plus Y_B for an external loading of 228 pounds.

Reference to *Fig.* 18 will show that the increase in loading on bearing *A* is less than the applied load since some of the tension in the shaft due to the preload has been relieved. This obtains up to the point where bearing *B* is relieved of preload, after which additional loading results in all of the applied loading being taken up by bearing *A*. Similar effects, would, of course, take place under a reverse direction thrust load.

FACE-TO-FACE DF MOUNT: The foregoing mounting arrangement is termed "back-to-back" or DB mount. It is also possible to obtain bearings in "face-to-face" arrangement or DF mount. In the DF arrangement, *Figs.* 19 and 20, a definite initial offset is allowed between the faces of the inner and outer rings. In this case, the housing cap must take up the preload offset Y_A plus Y_B. The deflection curve of *A* and *B* together is the same as in *Fig.* 16.

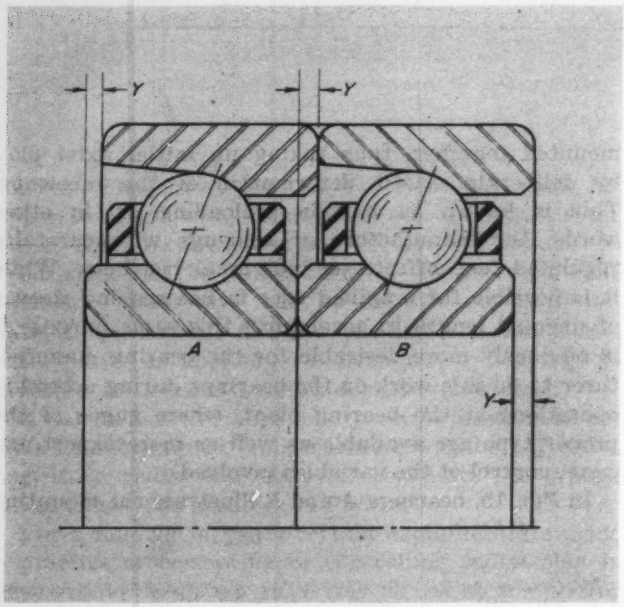
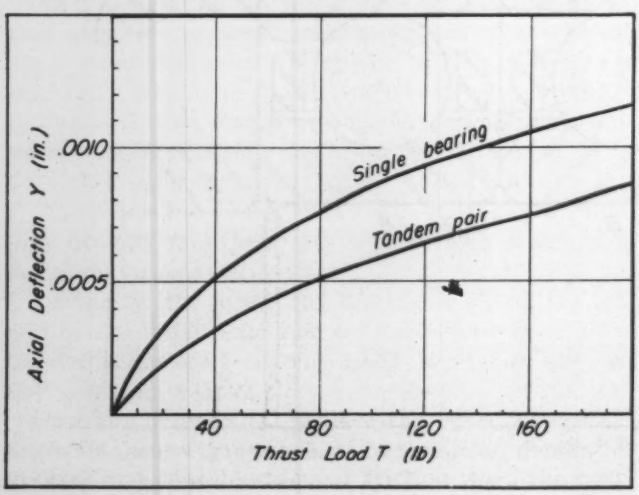


Fig. 21—Above—Duplex pair of bearings shown in tandem DT mount. Bearings must have equal offsets on each side

Fig. 22—Below—Curves showing relationship between deflection verus thrust load for single and tandem pairs



Thermal Expansion Requires Float

The DB mount is most frequently used since the preload is locked up on the shaft or spindle and the outer rings may be allowed to float in the housing to relieve thermal expansion effects.

The axial deflection rates of DB or DF pairs of the same size preloaded to the same amount are identical, as are the radial deflection rates. Radial deflection rates of low-angle preloaded bearings are of a magnitude of the order of 10 to 20 per cent (or less) of their axial deflection rates and except under the heaviest loads are not considered to be serious.

The deflection rate of single bearings can be varied by changing groove curvature radius or diametral clearance. To reduce axial deflection rate the groove radius can be reduced and diametral clearance can be increased. With preloaded bearings these same factors are involved, plus the variable of built-in or externally applied preload. Heavier preloads will reduce the deflection rate. Under high-speed conditions, to avoid heating from angular ball slippage factors, groove curvature radii may be increased and preload reduced. In general, close conformity bearings with close curvature should be used only at slow speeds.

TANDEM DT MOUNT: Such installations as aircraft variable-pitch propeller hubs may require stacked bearings of as many as six mounted in tandem preloaded against a single bearing. The multiple tandem sets are used to sustain the extremely heavy loads due to centrifugal forces during rotation and

OF TREMENDOUS IMPORTANCE in design is the judicious selection and proper application of antifriction bearings. While common types of standard grade bearings can be employed fairly successfully in various applications without exercising a great deal of care in design and assembly, the same is distinctly not true of the precision grades. Satisfactory results with superprecision ball bearings are directly related to the care used in selecting, applying, protecting and lubricating such bearings. Full cognizance of the design principles involved in selecting and applying these bearings will result in a much wider realization of their capabilities

the single bearing against which the tandem sets are loaded serves also to control axial movement from any reverse loading at standstill.

The main requirement for perfect tandem matching, *Fig.* 21 is that the bearings must have equal offsets *Y* on each side under any load. This means that the load deflection curve of each bearing comprising the pair must be identical. This requires that curvatures and diametral clearance of each bearing be uniformly maintained.

Typical deflection curves for single and tandem bearings are shown in *Fig.* 22. The slope of the deflection curve for the DT or tandem pair is obviously one half the slope of the curve for the single bearing.

UNIVERSAL OR THREE-WAY MATCH BEARINGS: Most manufacturers of precision bearings now make a practice of supplying duplex bearings ground with offsets such that the bearings will be properly loaded if mounted in any of the three ways: Back-to-back (DB), face-to-face (DF) or tandem (DT). For ideal conditions, the following requirements must be met:

1. The bearings comprising each pair must have their faces flush on each side at the specified preload (for interchangeable DB or DF mounting arrangements)
2. The bearings comprising each pair must have equal offsets on each side under any load (for DT mounting arrangement).

SELECTION OF PRELOAD VALUE: Users should always consult the bearing manufacturer before specifying values of preload in pounds, giving complete information as to speed and load as well as mounting arrangement and lubrication system desired. The higher the speed, generally, the lighter is the preload required. Conversely, for low speeds, higher preloads can be tolerated. Also with cooling by means of flood circulating oil systems or air-oil mist lubrication, higher preloads at high speeds can be tolerated.

Bearing Load Capacities

SELECTION FOR LOAD CARRYING CAPACITY: The various bearing manufacturers publish load ratings which differ considerably even considering identical types, sizes and ball complements. While the steel used is almost identical, manufacturing practices vary; also design factors such as curvatures, contact angles and retainer construction have made it difficult to achieve a complete standardization of load capacities and endurance life. It is not the purpose of this article to comment in detail on the situation.

However, many authorities agree that it is always good insurance to use bearings of more than adequate capacity provided the size is not so large as to make it undesirable from the speed standpoint. In recent years, several very definite trends can be noted. These are as follows:

1. The use of lighter section bearings is increasing. Bearing efficiencies have been improved by the increasing availability of better quality steel, better surface finishes and better manufacturing techniques
2. Heavier sectioned bearings are diminishing somewhat in popularity as the trend continues to lighter weight and more efficient constructions
3. Spindles are increasing in speed to achieve more efficient grinding
4. Faster electric motors are being built using high-frequency power supply requiring more accurate and longer lived bearings
5. Demands for better bearing accuracy are being increasingly met by the bearing industry.

All of the above factors have focused more careful attention on the selection of the proper bearing. In TABLE IV is given a summary of selection factors which it is hoped will be useful in clearing up some of the confusing situations which arise during the course of a machine design for which bearings are being selected.

Fourth part in this series on superprecision ball bearings will appear in the February issue of MACHINE DESIGN. This part will cover application and mounting design factors.

Miniature Typewriter

SMALLEST, lightest, and most compact typewriter in the world, the miniature machine shown below is manufactured by British Typewriters Ltd., London. Of all-metal construction, the typewriter with its detachable carrying case weighs only 8½ pounds. Overall dimensions with the case are 11 x 11x2⅜ inches. Designed for hard use and capable of producing six carbon copies, the machine has a standard keyboard, 9¼-inch typing line, full length ½-inch ribbon, and automatic ribbon reverse. Advantages include good typing visibility and quiet operation.

Selecting Electric Servomotors

Important design considerations which must be taken into account in making a choice of a mechanical rotation servomotor

By Robert S. Edwards
Sperry Gyroscope Co.
Great Neck, L. I., New York

ACCEPTED definition of the term servomechanism usually applies the word to that class of device in which the difference between output and input quantities is used to control the output in such a way as to make it agree with the input. Servomechanisms, or servos as they are usually called, can be roughly divided in the instrument field into process controllers and mechanical rotation servos. This paper deals with the more commonly used latter types.

A mechanical rotation servo has for its output and usually for its input a shaft rotation, for example the remote positioning of antiaircraft guns so that the aiming point of the guns agrees with the calculated aiming point as computed by a director. Often the output of the computing mechanism is a shaft of very low torque capacity. The guns require high torque and are usually located so that it is impractical to connect the two by any means except electrical wires. A selsyn or synchro data system is used to measure the error, or difference in angle, between the guns and the director and this difference is used to actuate the servomotor on the guns in such a way as to reduce the error to zero.

FACTORS DETERMINING CHOICE: A number of factors are involved in the choice of a servomotor to be used for a particular application, the most important of which is performance. Each application has its own requirements as to power or torque required to operate the load, characteristics of the load, maximum speed of operation, and allowable error under various conditions. A commonly used figure of merit for servomotors is the ratio of maximum stalled torque to inertia. This figure of merit is useful as a general guide, but should be used with caution since there are other important factors to consider. One of these other factors is the delay in the buildup of torque at the output shaft after a control signal is applied to the input terminals of the servomotor. It is interesting to note that in some cases where a large servomotor time delay is involved, the stability of the system can be improved by adding inertia to the load. This servomotor time delay may be due to the impedance that couples the motor to its controlling amplifier or it may be inherent in the design and construction of the particular servomotor.

Data System. The type of data system or error measuring device may affect the choice of a servomotor to a certain extent. If synchros or other electrical devices are used for the data system it may be most convenient to use an electric motor, and if a pneumatic error device is used, it may be most convenient to use a pneumatic servomotor, *Fig.* 1. There have been a number of devices such as

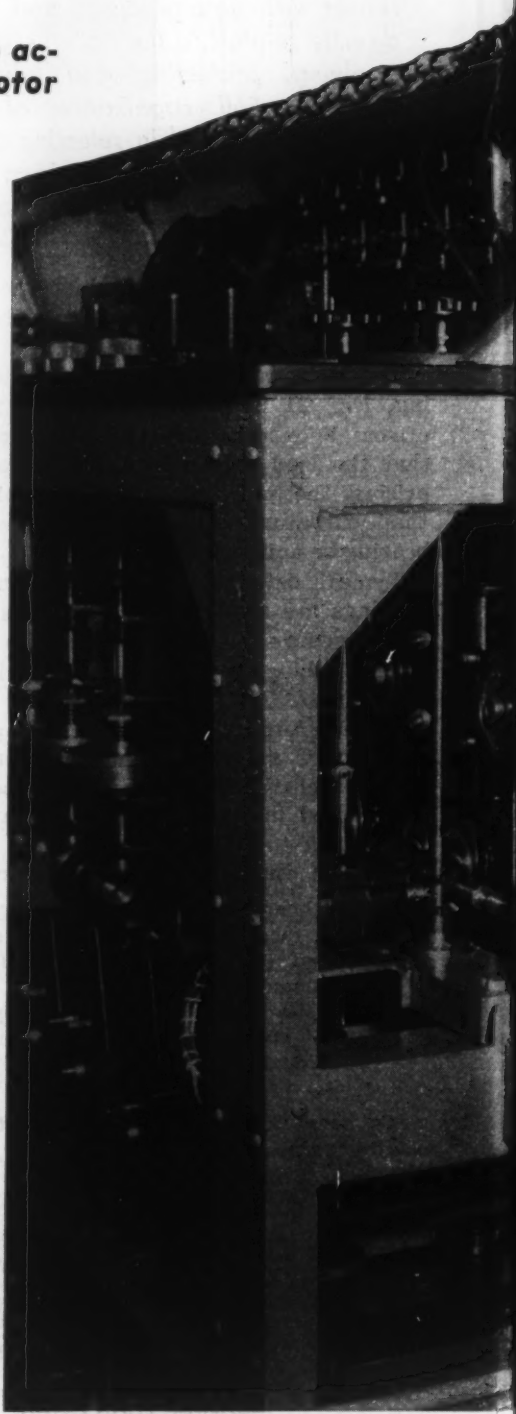
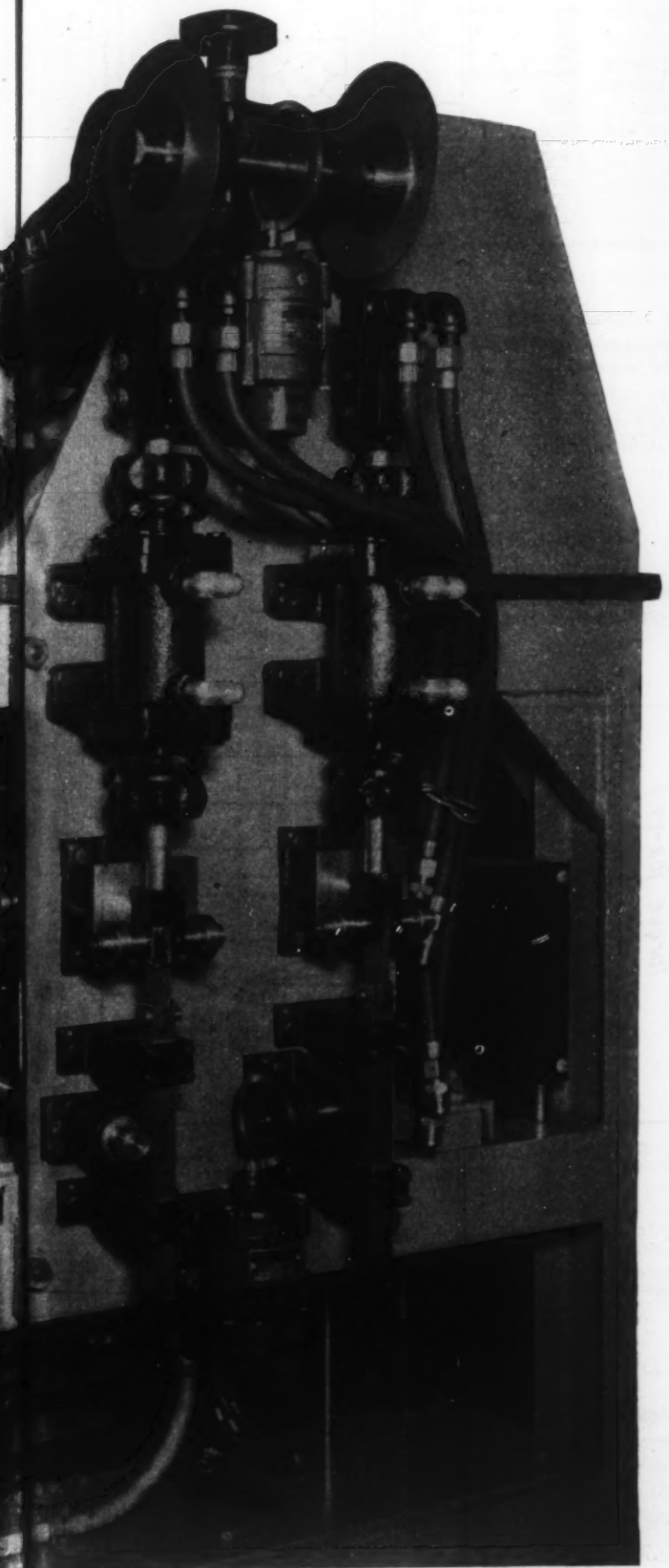


Fig. 1—Combination electric-pneumatic servo system is used in this calcu-

This article is based on a paper presented at the recent conference of the Instrument Society of America at Philadelphia.



lating machine. Air-jet sensing device at top follows the cam contours and top input selsyn motor operates the cams. Bottom selsyn generator transmits the position of the air cylinder to translate fuctions electrically. Photo courtesy Askania Regulator Co.

magnetically controlled high-speed valves developed, however, which permit the use of a combination system. This article, however, will cover only the common types of electric servomotors.

Power. The amount of power required to control a particular type of electric servomotor should also be considered. Generally the smaller the control power, the more convenient the servomotor is to use, but this may lead to other complications such as increased time delays that cannot be tolerated. Another important determining factor is the source of power available. In most industrial applications, 60-cycle alternating current is available and in some cases direct current may be used. For aircraft applications, however, the power sources are usually low-voltage direct current, 400-cycle alternating current, or in some cases alternating current of constant voltage but of frequency which varies between 300 and 1600 cycles per second.

Size and Weight. The weight and size of the servomotor and its associated equipment may not be extremely important for industrial applications, but in aircraft use or in any system that must be readily transportable the size and weight are of utmost importance.

Service. Another important consideration is the vulnerability of the servomotor to service difficulties. For industrial applications, the extremes of temperature, humidity and altitude are not as rigorous as for aircraft ap-

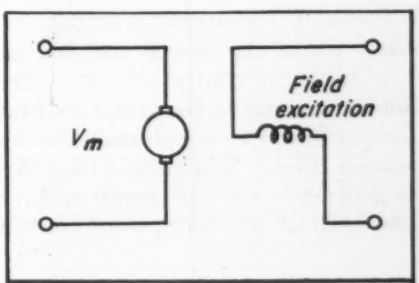


Fig. 2 — Right — Schematic circuit for a separately excited shunt motor

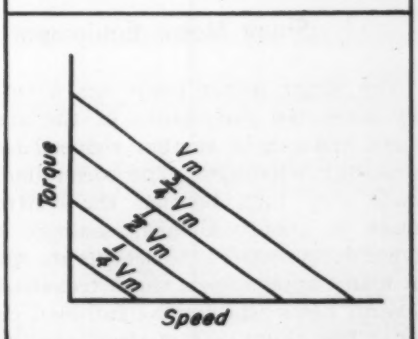


Fig. 3—Right—Family of torque-speed curves obtained for various values of applied voltages with the motor in Fig. 2

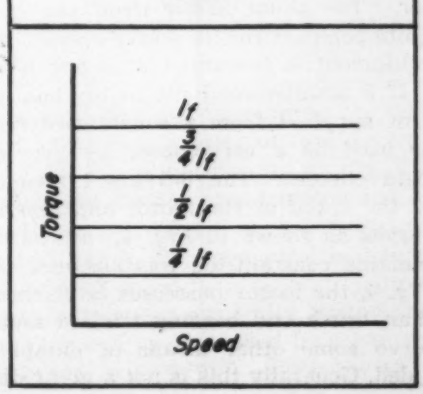


Fig. 4—Right—Shunt-wound d-c motor with constant-current source has a family of torque-speed curves with torque independent of motor speed

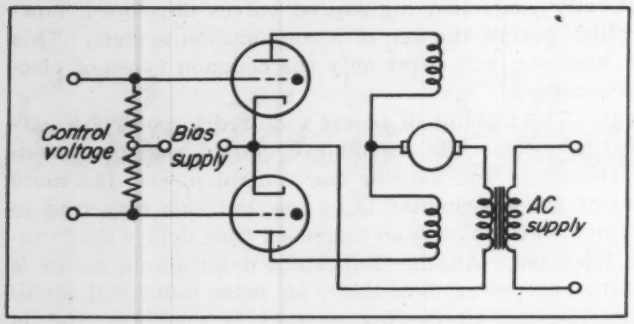


Fig. 5—Thyratron circuit for field controlled d-c motors

plications, but industrial equipment must generally go for long periods of time without service and must have a long life. Aircraft and military applications generally do not require such a long life, but dependability during normal operating life must be very good, and operation is required over wide variations of climatic conditions.

D-C SERVOMOTORS: A conventional shunt-connected d-c motor can be used as a servomotor. Using the separately excited motor shown schematically in *Fig.* 2 with a constant field excitation, the family of torque-speed curves shown in *Fig.* 3 are obtained for various values of applied voltage. These curves indicate that this motor produces a constant torque at all speeds. In the light of the determining factors discussed, a serious disadvantage is apparent in that nearly all of the power supplied to the motor must come from the control circuits. The physical limitation of wire size in the armature winding also requires that the power be supplied at a comparatively low impedance level. This means that thyratrons or a motor-generator set are required to supply the armature, both of which types of control have been used.

Shunt Motor Equipment Heavy

The shunt motor itself has a very small time delay since the inductance of the armature circuit is small and can be further reduced by the use of compensating windings. The torque-inertia ratio can be made very high because the control circuit can be made to supply a large amount of current under dynamic conditions to accelerate the motor rapidly. In many applications these transient currents can be several times the normal full-load current of the motor. The shunt motor itself can generally be made quite compact for its power output, but the associated equipment is generally large and heavy.

If a shunt-wound d-c motor has its armature current supplied from a constant-current source, it can be used as a servomotor by providing controllable field current. The developed torque is independent of the speed of the motor and results in a family of curves as shown in *Fig.* 4. If the armature current remains constant, as was assumed for the curves of *Fig.* 4, the motor possesses no natural damping other than brush and bearing friction and when used in a servo some other means of damping must be provided. Generally this is not a great disadvantage since

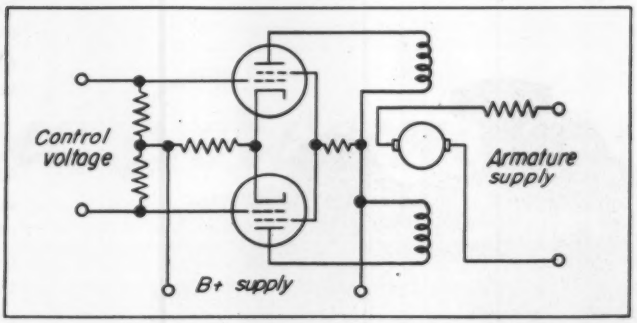


Fig. 6—Above—Vacuum tube circuit for field controlled d-c servomotors having high-impedence field windings

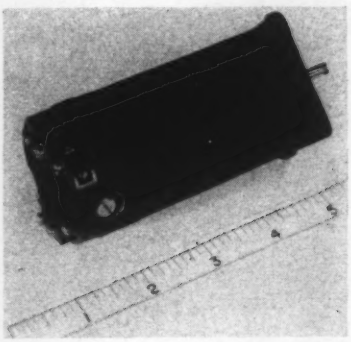


Fig. 7—Right—Small d-c field-controlled servomotor for aircraft applications

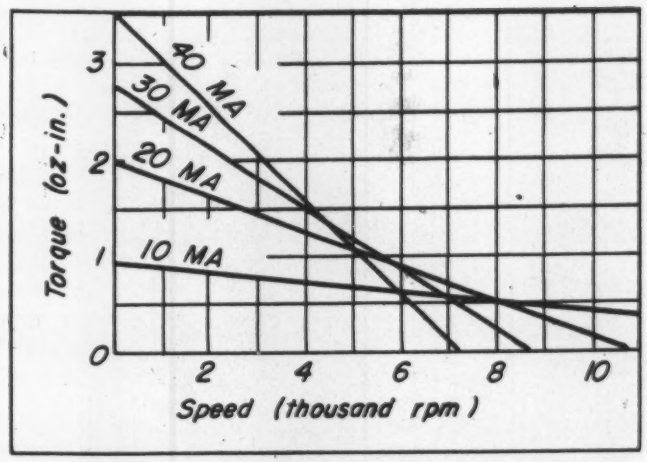
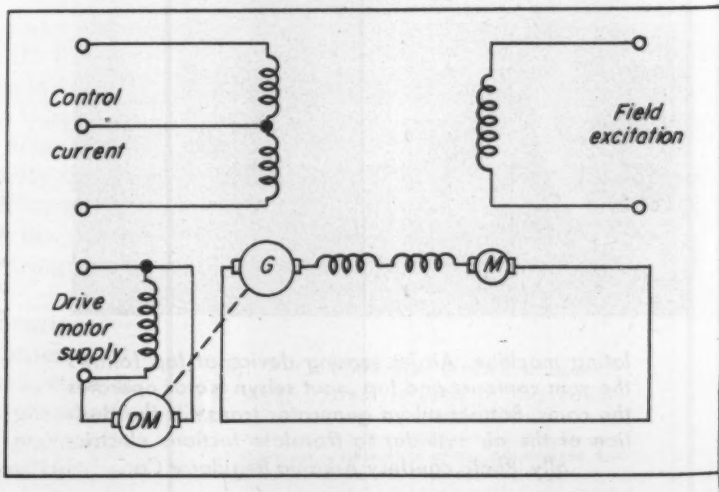


Fig. 8—Above—Torque-speed curves for the servomotor shown in Fig. 7

Fig. 9—Below—Schematic circuit for Ward-Leonard d-c motor-generator servomotor



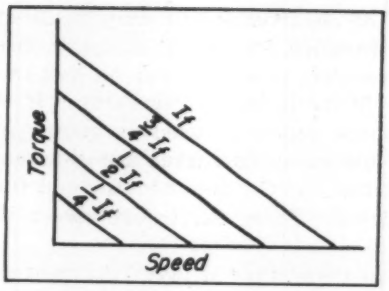


Fig. 10 — Left — Family of torque-speed curves for the d-c motor-generator servomotor arrangement in Fig. 9

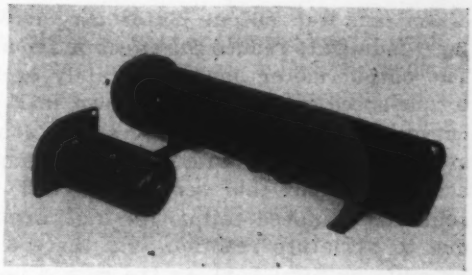


Fig. 11 — Right — Three-axis generator and output motor designed for use in an aircraft autopilot

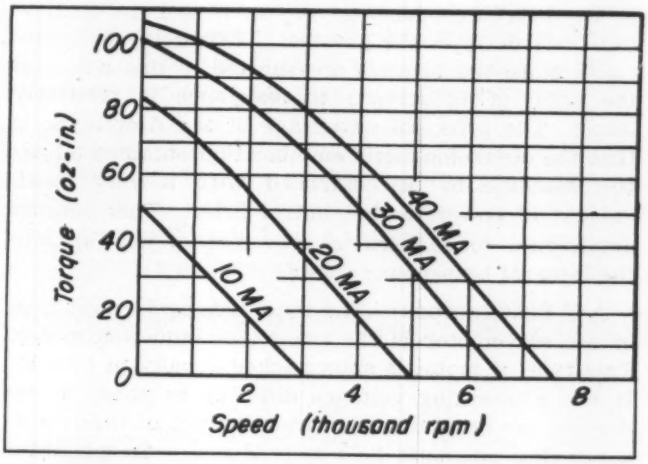


Fig. 12—Above—Family of torque-speed curves for the autopilot servomotor shown in Fig. 11

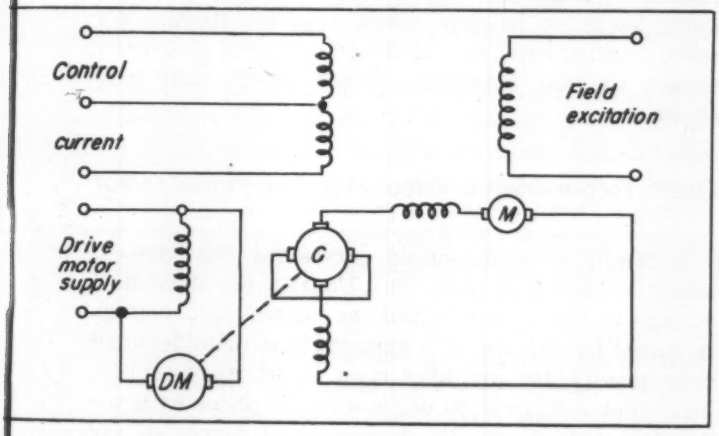


Fig. 13 — Above — Schematic circuit for the amplidyne motor-generator type servomotor

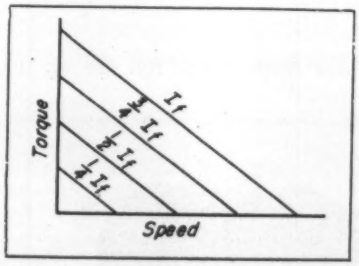


Fig. 14—Left—Family of torque-speed curves for the separately excited shunt servomotor in Fig. 13

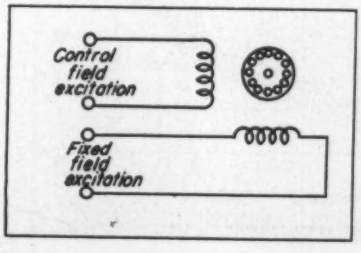


Fig. 15—Left Below—Most commonly used two-phase a-c servomotor is shown in this schematic layout

the amount of damping that must be provided to produce a high-performance servomechanism is large compared to the natural damping of the motor.

Motors designed for field-control applications usually have a split-field winding and there are two circuits commonly used to control this type of motor. One circuit uses thyratrons connected to the motor as in *Fig.* 5. In this circuit the motor fields are wound for the same current as the armature. This same type of circuit can be used with high-speed relays in place of thyratrons. The other control circuit commonly used with this motor is shown in *Fig.* 6 and employs vacuum tubes to control fields that are wound for high impedance. The armature of the servomotor is supplied through a dropping resistor from d-c supply. The current through the armature may be considered constant only so long as the generated emf of the motor is small compared to the armature supply voltage. In actual servo applications it is found that good control can be obtained at speeds which produce considerably reduced armature current. The delay in this type of motor is due to the inductance of the field circuit and generally can be made quite small by using beam-power or pentode tubes in the control circuit. This type of control is relatively inefficient in that a large proportion of the armature supply power is dissipated in the external resistor, but this fact is outweighed in some applications by the small amount of associated control equipment needed.

Tachometer Generator Used For Damping

A particular motor that has been developed for aircraft applications is shown in *Fig.* 7. This motor is designed to be operated by type 6AQ5 miniature vacuum tubes. *Fig.* 8 shows torque-speed curves for this motor. The motor shown has an alternating-current tachometer-generator on the same shaft as the motor to furnish damping signals that are introduced as feedback in the amplifier circuit to stabilize the servomechanism.

There are two types of motor-generator d-c servomotors which have been used considerably in the last few years. One of these uses a more or less conventional field controlled d-c generator to supply the armature of a separately excited shunt motor and is known as a Ward-Leonard drive. A schematic of this drive is shown in *Fig.* 9. The generator is driven at a more or less constant speed by a separate motor. The fields of the generator are generally wound for high impedance so they can be controlled by a pair of vacuum tubes connected in push-pull. Both the gen-

erator and the output motor may have compensating windings to reduce the effect of armature reaction. The output motor has a separately excited field and torque-speed curves are as shown in *Fig.* 10. These curves are similar to the curves for a shunt motor and are subject to the same general comments. In an actual example this servomotor will tend to give somewhat reduced torque for high armature current due to armature reaction, and the spacing may not be quite uniform between the curves because of nonlinearity in the magnetization curve for the generator. This type of servomotor can be used to produce a high-performance servomechanism. If the generator is designed to deliver large currents to the output motor for a short time very high accelerations can be obtained.

Ward-Leonard Time Delays Small

There are two time delays between field voltage of the generator and build-up of torque in the output motor. One of these is due to the inductance of the control field of the generator. This delay can be minimized by the use of beam power or pentode tubes in the amplifier output stage just as in the field control motor. The magnitude of this delay will depend on the size of the machine but will generally be quite small for machines under one-half horsepower rating. The amount of power required to excite the generator field is within the capabilities of receiving type vacuum tubes for systems of under one-half horsepower, but for large machines transmitting tubes or some other means of control must be used.

This type of servomotor is usually inefficient since the losses of three rotating machines are involved; the drive motor, the generator and the output motor. For some applications where several servos are involved, the efficiency can be increased considerably by using one drive motor to operate several generators. One such application is an automatic pilot for aircraft which requires servos for ailerons, rudder and elevators. The photograph of *Fig.* 11 shows a three-axis generator and output motor designed for use in an autopilot. The drive motor operates from the airplane d-c supply as do the fields of the output motors. Torque-speed curves for this servomotor are shown in *Fig.* 12. The maximum acceleration or torque-inertia ratio of this motor at stall is 25,000 radians per second per second. Weight of each output motor is 3 pounds 10 ounces. The power motor and three generators weigh 17 pounds 14 ounces.

The second type of motor-generator d-c servomotor uses a special generator, the Amplidyne, which has built into it a stage of electromagnetic amplification. The control field is designed for use in the plate circuit of a push-pull vacuum tube amplifier as was the control field of the Ward-Leonard generator. If a separately excited shunt motor is used as shown in *Fig.* 13, a family of torque-speed curves are obtained that are similar to those for the shunt motor and for the Ward-Leonard drive. These curves are shown in *Fig.* 14.

The Amplidyne has three time delays; the control field, the quadrature axis and the direct axis. Usually the direct axis delay is very small and the quadrature axis delay is the greatest. This delay is appreciable since the brushes are shorted in this axis and the ratio of inductance to resistance is relatively large. The principal advantage of the Amplidyne is that the electromagnetic amplification obtained allows the machine to be controlled with a very small amount of power in the control fields. This permits amplidynes to be used as servomotors well up into the integral horsepower range.

A-C SERVOMOTORS: The most commonly used type of a-c servomotor is the two-phase induction motor. This type of motor is shown schematically in *Fig.* 15. If two alternating voltages differing in phase by 90 degrees are applied to the two windings of the motor, a rotating magnetic field is produced. An armature wound with low-resistance wire will have its maximum torque near synchronous speed, while a high-resistance armature will produce peak torque at a much lower or, in some cases, negative speed. For servo applications, the winding resistance is usually chosen so that maximum torque occurs near zero speed.

Good Torque-Inertia Ratio with Two-Phase Motor

A family of torque-speed curves for this type of motor is shown in *Fig.* 16. Usually the fixed field voltage is held constant and the control field voltage is varied by the use of a vacuum tube amplifier, and consequently, the amplifier must be designed so that its output voltage is 90 degrees out of phase with the line. In actual use, the torque-speed curves of the

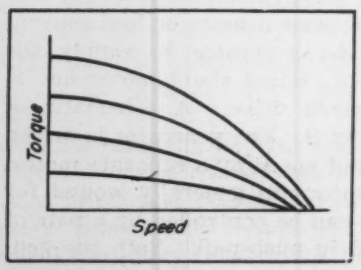
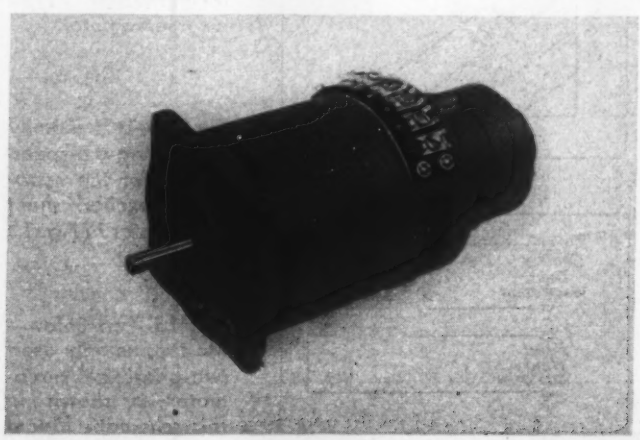


Fig. 16—Left — Family of torque-speed curves for the servomotor in Fig. 15

Fig. 17—Typical field-control shunt motor for use on a-c



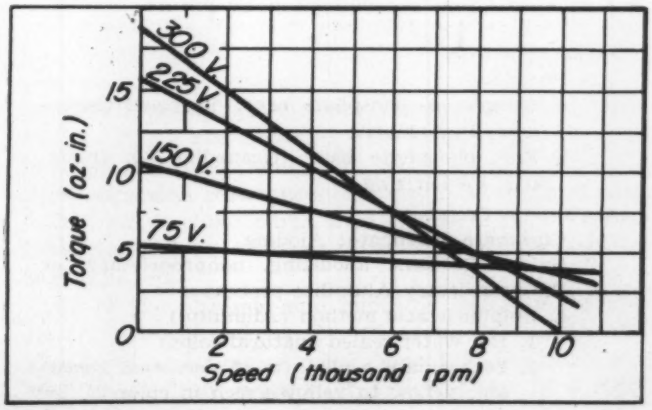
motor will depend somewhat on the circuit used to drive the motor since the impedance of the motor will change with speed. This type of motor requires that a fairly large portion of the total motor input power be supplied by the control field. The ratio of fixed-field power to control-field power is generally not greater than three-to-one for good servo performance. In small servos of this type the maximum control field is often greater than the fixed field power in order to reduce the heating of the motor under steady-state conditions, but still allow high peak power for transient loads. The torque-inertia ratio of the two-phase motor can be made quite good in the small sizes, and the delay in the control field excitation is very small if the field is not resonated.

Induction motors can be designed for either 60 or 400 cps and find use both in ground and aircraft work. Limitations on the size of the amplifier generally restrict their use to servos rated at less than one-tenth horsepower although larger motors have been used with thyratron control circuits.

Field-Control Shunt Motor Requires More Iron

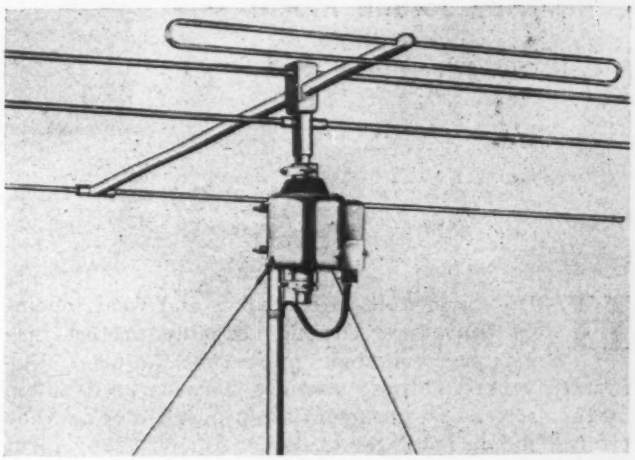
The field-control shunt motor for operation on direct current can also be used on alternating current if proper precautions are taken in the design of the motor and of the control circuits. For a-c operation it is desirable to make the field structure of laminations to reduce eddy-current losses. The general family of torque-speed curves for the d-c motor shown in *Fig.* 4 apply equally well to the a-c motor. For a-c operation the output stage shown in *Fig.* 6 becomes an a-c amplifier and the armature is excited from an a-c line. It will be noted that if one of the brushes of the motor bridges from one commutator bar to the next, one coil of the armature is short circuited and the coil is in a plane to have maximum flux linkage with the control field. A current is inducted in this short circuited coil that does not produce torque but does require additional power input to the control field and increases armature heating. This effect can be minimized by using a large number of commutator segments and by the use of high-resistance brushes to limit the current flow in the short-circuited coil. This type of motor requires a relatively large iron structure for both stator and rotor and therefore generally has a poor torque-inertia ratio. The delays in the motor are small unless the field is resonated. It is unlikely that this type of motor could be used successfully at frequencies higher than 60 cps because of the high iron loss at high frequencies. A typical motor of this type is shown in the photograph of *Fig.* 17. Torque-speed curves for this motor are shown in *Fig.* 18.

Fig. 18—Torque-speed curves for the servomotor shown in Fig. 17 for use on a-c



Remote Training of Antenna

MAXIMUM efficiency of high-frequency antenna is realized with the remote control device shown in the photograph, below. Merely moving a switch on a control box located near the television, FM or other high-frequency receiving equipment causes the "beam" type antenna to rotate horizontally in either direction. By listening to the volume of a FM receiver, or by watching the screen of a television set, the antenna can easily be "beamed" in on the bearing giving the best reception. Designed by Alliance Manufacturing Co., the two-part remote control system



can be installed on equipment having a center antenna post of 1⅜ inches or less. A zinc die-casting, bolted to the top of the antenna mast, houses the rotating or drive mechanism. The split-phase, reversible, capacitor type drive motor is operated on 24-volt, 60-cycle current supplied by a step-down transformer in the control box, giving an antenna shaft speed of 1 rpm through a 3000 to 1 gear-train reduction. Sliding stops limit the travel of the antenna to 365 degrees, an indicator light showing when the end of travel has been reached. Weatherproofing the drive unit, the most serious problem encountered in the design of the mechanism, was solved by using brass for all exterior fittings, cadmium-plated steel parts in the drive unit, and by placing a close-fitting neoprene "weathershield" on the rotating shaft where it emerges from the gear box. Special low-temperature lubricating oils protect all moving parts.

Protective Coatings

characteristics and applications of chemical-conversion finishes

By Joseph Mazia
Metallurgist
American Chemical Paint Co.
Ambler, Pa.

HIGHLY resistant to corrosion and wear, chemical conversion coatings capably protect machine parts against premature failure. Unusually versatile, these coatings may be used either by themselves or to augment the properties of another type of finish, paint for example, *Fig.* 1. They form an integral chemical part of the metal to which they are applied and consequently are strong, tractable and resistant to chipping. Finishes of this type are applied by means of chemical baths, the constituents of the bath reacting with the basis metal to form an insoluble oxide or salt. They are particularly adaptable to inexpensive, automatic, mass production techniques, *Fig.* 2.

The diversity of application of these coatings is well illustrated by their use in the automobile. Zinc-iron phosphate finishes are used under the paint, *Fig.* 1; the pistons, if cast iron, are coated with a manganese-iron phosphate layer—if aluminum they are anodized. The fuel pump, a zinc alloy die casting, has a chromate coating sometimes topped with a clear lacquer. Assorted hardware such as nuts, bolts, pins and washers bear a zinc or manganese-base phosphate coating impregnated with a small amount of chromic acid and rust preventive oil; the camshaft, rocker arm, spider, jack hook and other parts with rubbing surfaces are coated with manganese-iron phosphate.

As has been indicated, chemical conversion coatings provide excellent protection without requiring the use of overlaying coatings. They increase the protective value of paints and platings or they can be used to provide wear resistance. These three properties will be discussed in that order.

CORROSION PREVENTIVE COATINGS: Broadly speaking this subject can be broken down into the following classes of finishes which will withstand weathering without being supplemented by paint:

STEEL COATINGS
1. Phosphate
   a. Manganese phosphate base: Thermoil Granodine, Parcolubrite
   b. Zinc phosphate base: Granodine 30, Ircoizing, Parkerizing

ALUMINUM COATINGS
1. Chromate-phosphate: Alodine
2. Oxide: Galvanic anodizing, nonproprietary, or the proprietary Alumilite processes
   a. Sulphuric acid method (Alumilite)
      1. Hot water sealed (natural color)
      2. Dichromate sealed (most corrosion resistant, yellow to yellow-green in color

Fig. 1—Chemical conversion coatings of the ferric-phosphate type are used for under-paint protection of automobile bodies

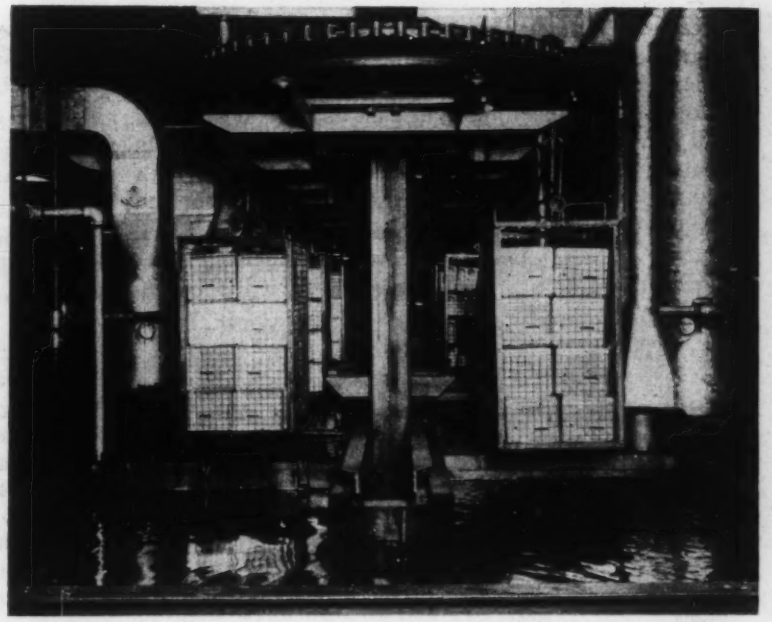
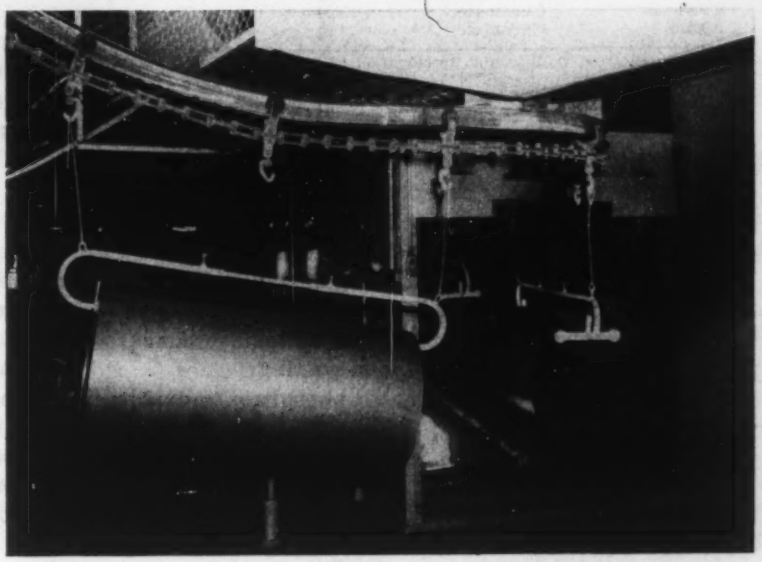


Fig. 2—Above—Automatic mass-production techniques are employed to coat aluminum temperature-regulator covers with chromate phosphate

Fig. 3—Below—Shells for automatic hot water heater are protected by phosphate coatings



b. Chromic Acid Method
   1. Dichromate sealed (Alumilite)
   2. Unsealed (usually used as a paint base)
   3. Dyed (black dye is most generally used although certain other colors can be deposited)

ZINC AND CADMIUM COATINGS

1. Chromate
   a. Immersion processes: Zinodine, Cronak Iridite, Anozinc Dip
   b. Galvanic anodizing: Anozinc.

The coatings for steel are applied by immersion of the cleaned metal in balanced solutions of phosphate chemicals. The surface is converted to a complex crystalline-phosphate coating integral with the basis metal. Parts are usually given a final aqueous rinse in a weak chromic acid bath, which greatly enhances their corrosion resistance. This type of finish is used widely on machine parts, heating units, *Fig.* 3, tools, firearms, and on such machine elements as metallic belt links, etc.

All of the chromic-acid anodized coatings for aluminum are colored as formed from the electrolyte. The depth and type of color depend on the alloy and may range from a gray or yellow-green to a light green. The oxide coatings discussed are produced by electrolyzing the aluminum alloys as anodes in an appropriate acid electrolyte. Most processes of anodizing use direct current although some use alternating current.

Zinc and Cadmium Coatings

All of the zinc and cadmium protective processes result in protective films containing hydrated oxides of chromium in a complex combination and, sometimes, zinc chromate. They effectively reduce the tendency of zinc to corrode in humid environments in the type of corrosion called "white rust," zinc "bloom" and zinc "pest." There are differences in the type of control, economy and chemistry of the above processes and the end results vary in quality for various

applications. However, all of them more or less efficiently serve the same function.

Zinc or cadmium surfaces—whether electrodeposited, applied by hot dipping or cast as part of an alloy—will generally benefit from the chromate treatments described. U. S. Army specifications place a high premium on the chromate treatment* of zinc and cadmium platings over untreated platings, TABLE I.

Zinc or cadmium platings provide sacrificial protection and in so doing, leave a residue of white corrosion products which may interfere with the functioning of parts. The addition of a chromate finish to these platings prevents this condition. Thus, the use of chromate-treated zinc or cadmium electrodeposits would be indicated on machine components which require a high degree of protection against rust both of the white and red variety. Electrical, telephonic and other communications and signal equipment make wide use of this type of conversion coating.

TABLE I

Salt-Spray Resistance Requirements of Zinc and Cadmium Electrodeposits*

Plate Thickness (inch)	Conversion Coating	Time for Appearance of White Salts (min. hours)	Time for Appearance of Red Salts (min. hours)
Zinc			
0.001	None	..	72
0.0005	None	..	48
0.00015	None	..	24
0.001	Chromate	24	96
0.0005	Chromate	24	72
0.00015	Chromate	24	48
Cadmium			
0.005	None	..	72
0.0003	None	..	48
0.00015	None	..	24
0.005	Chromate	24	96
0.0003	Chromate	24	72
0.00015	Chromate	24	48

* Abstracted from U. S. Army Specification 57-O-2C.

Summarizing, oil or wax-treated phosphate or oxide coatings can be used on ferrous metals, chromate-phosphate or oxide chromate can be used on aluminum and chromate coatings on zinc alloys.

* Also covered by ASTM Tentative Specification B201-45T.

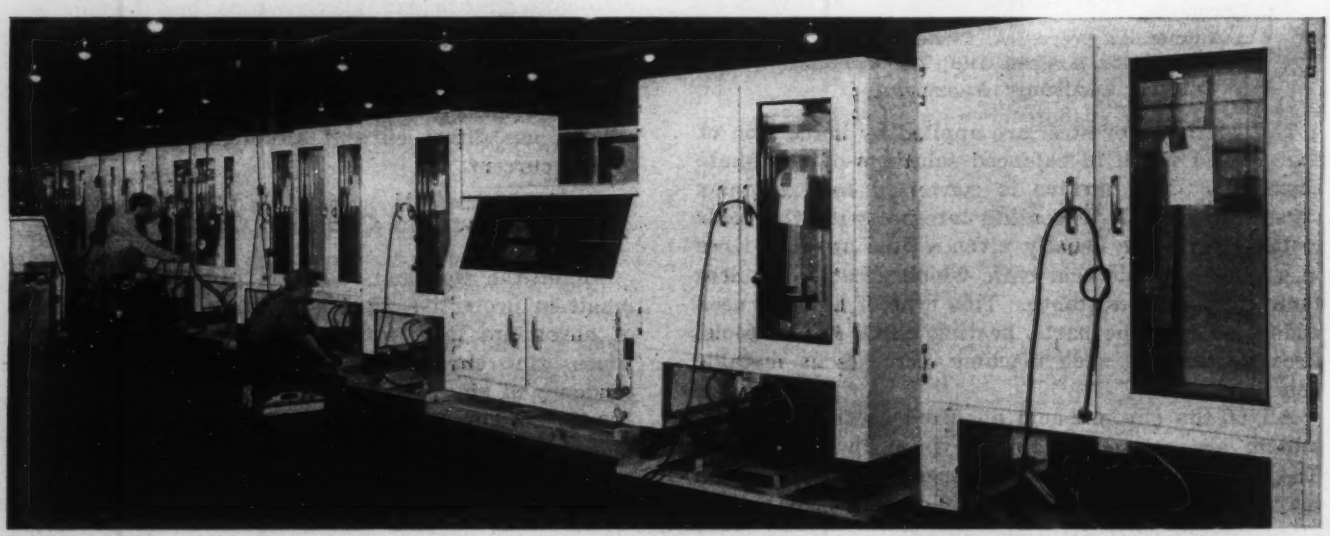
PAINT UNDERCOATINGS: It is generally recognized that paint, as the skin of the structure, should be applied on a sound foundation. Sound pretreating practice is as important as the use of a good paint applied properly. To generalize on the kind of surface desirable on any metal to be painted the following may be listed:

1. It should be free from dirt (grease, oil, flux residues) rust and scale
2. It should be as free as possible from corrosion-accelerating salts and any form of moisture with the exception of certain chromium salts or phosphates. This means the absence of any residues which might result in developing pressures under the paint film. These residues on metal surface are as bad or worse than excessive water-soluble materials in the paint film itself
3. It should contain for best results a passive, water-insoluble, stable, nonconducting chemical conversion coating of the phosphate or chromate type
4. It should be of such a texture as to present a large surface area for mechanical adhesion of the coatings. In certain cases, for example chromate-phosphate finishes, this roughened surface is not necessary because of the excellent bonding of these films with many organic finishes
5. It should contain a controlled amount of corrosion-inhibiting material such as hexavalent chromium.

Phosphate Finishes

Phosphoric acid-detergent systems are simplest means available for derusting cleaning and conditioning most metal surfaces. More efficient, however, than the acid cleaners in preserving the bond between paint and metal are the ferric phosphate, manganese-iron phosphate, and zinc-iron phosphate conversion coatings. These finishes are primarily for use on steel although manganese-iron phosphate has been used successfully on other metals and zinc-iron phosphate may be used on zinc surfaces. All of these

Fig. 4—Under-paint protection of commercial refrigerators is provided by zinc-iron prosphate coating



coatings are applied from acid-phosphate salt baths which convert the surface of the metal to crystalline, insoluble, paint-retentive phosphates. Most frequent application of zinc-iron phosphate and ferric phosphate is by power spray washers of various types. Manganese-iron phosphate is applied by an immersion process. An iron-chromate finish is also used on steel in preparation for painting. Automobiles, refrigerators, *Fig.* 4, typewriters, and ordnance equipment are some of the things which most commonly bear these types of finish under the paint.

New chromate-phosphate coating (Alodine) for aluminum surfaces, *Fig.* 5, is an excellent treatment for preparing aluminum for painting. It is simpler to apply than anodizing since it does not require electrolytic equipment nor special, lengthy sealing treatment. It also involves a shorter process than the alkaline chromate processes.

Paint Bonding to Zinc

Zinc and its alloys represent a special problem in paint preparation, owing to the reactivity of the metal. The familar peeling of paint from galvanized parts is caused by the reaction of zinc with fatty acids of the paint vehicle to form zinc soaps at the interface between the metal and the paint. Other metals tend to do this too but zinc is the worst offender. The answer to the problem lies in converting the surface of the metal to a nonmetallic substance by chemical reaction. To do this there are available such phosphate processes as Lithoform and Bonderizing, and a variety of chromate proceses—Zinodine, Cronak, Iridite and Anozinc. It should be borne in mind, however, that the chromate films are not universally applicable under all paints. Blistering in humid atmospheres occurs with some paints when applied over chromate films. For this reason each specific paint should be checked before it is used over chromate coatings.

Magnesium and its alloys present a problem insofar as corrosion is concerned. Although surprisingly corrosion resistant against weathering when uncoupled with other metals, it will not hold up very well when in contact with them owing to its tendency to become anodic and dissolve. There is however, a wide variety of finishes, both electrolytic (anodizing) and simple immersion, available to prepare magnesium for painting. Most of the chemical finishes are chromate coatings.

Fig. 5 — Aluminum control housing having organic finish, is precoated with chromate phosphate to provide better paint bond and increased corrosion resistance

JOSEPH MAZIA headed the protective finishes section of the Ordnance Laboratory, Frankford Arsenal, where he was responsible for the specification of many of the finishes now used as standard on U.S. Army ordnance equipment. He is a member of the Philadelphia branch of the American Electroplater's Society and chairman of project No. 7 research-directing subcommittee. He is a graduate of the University of Pennsylvania and did graduate work at the Colorado School of Mines, Temple University and the University of Pennsylvania

FRICTION SURFACES: One of the most inexpensive and practical methods of preventing welding, seizing and galling of friction surfaces is to coat the metal in such a way as to prevent metal-to-metal contact. Chemical conversion coatings serve well in this type of service. On machine parts of steel or cast iron which may be oiled periodically or which operate in oil, or gasoline, manganese iron phosphates give excellent service. They are being used, for example, on automotive friction parts such as pistons, piston rings, rocker arms, camshafts, levers, and spiders, *Fig.* 6. Owing to the strategic nature of tin, and the high cost of tin plating, phosphate finishes have replaced it in many instances where it has been used to facilitate break-in or wearing-in of parts, often with improved performance. The phosphate film is superior to tin because of its ability to absorb and hold oil and because it is accompanied by an etch pattern, in the basis metal, which is ideal for bearing surfaces. Anodizing has been widely used on aluminum friction surfaces to prevent scuffing, scoring, welding and galling.

Avoid Moisture Traps

DESIGN CONSIDERATIONS: Designers would do well to study various types of equipment to determine where paint failures are most likely to occur after years of service. Automobiles are a good example. Most severe corrosion would be found under fenders which are subject to abrasion, salt corrosion and water. Areas that trap moisture, such as the interior of doors without provision for drainage, shelf-like structures, areas adjacent to chromium trim and edge areas, are all sore spots. Based on the experience of the war years when autmobiles hit the proving ground

of longevity, automotive finishing engineers have upped their specifications on all paint jobs. Quality control of pretreatments has become standard practice, inconspicuous parts which never used to experience paint are being painted, underbody protective compounds have been developed, specifications for paint coverage have been increased, and the situation is improving apace.

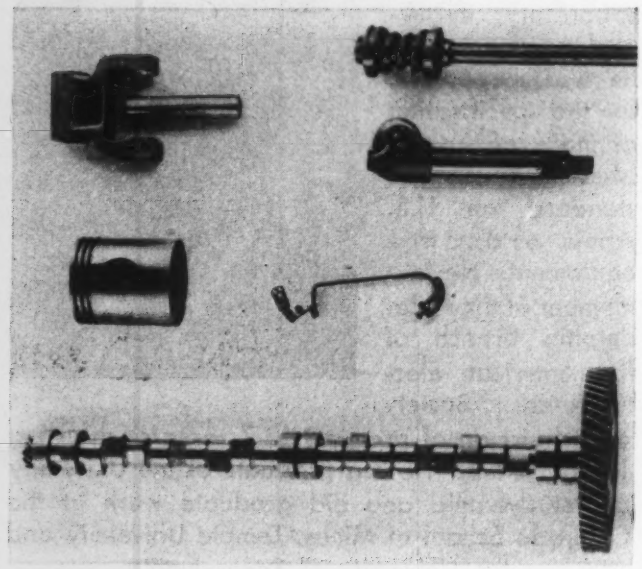


Fig. 6—Wear and corrosion resistance of automotive components is provided by manganese-iron phosphate conversion coatings

Design Rules

In designing equipment which is to be protected by conversion coatings and paint there are a few good rules to follow:

1. Specify an adequate pretreatment practice
2. Choose a protection system adequate for the intended service and one which has been adequately tested over the type of pretreatment which is specified
3. Avoid sharp edges (use rolled-over edges instead), fillet corners generously, avoid re-entrant angles
4. If there must be enclosed spaces which can trap and hold moisture through direct leakage or condensation, provide holes for adequate drainage
5. Provide holes for drainage during the chemical treatment. This is necessary to prevent drag-over of the various solutions used in the pretreatment cycle.

PREDICTION OF PERFORMANCE: As with organic finishes and electrodeposited coatings, chemical conversion coatings have long been subject to extravagant claims of durability on the basis of performance in accelerated tests. It would, indeed, be fine to be able to say with any degree of accuracy that "Finish *A* resisted 150 hours salt spray, therefore, when applied to an automobile fender, it should last for three years;" or "Finish *B* looked fine after 1420 cycles in the Weatherometer, therefore, when applied to a compressor housing, it should last ten years."

TABLE II

Salt Spray Requirements of Phosphate and Oxide Finishes*

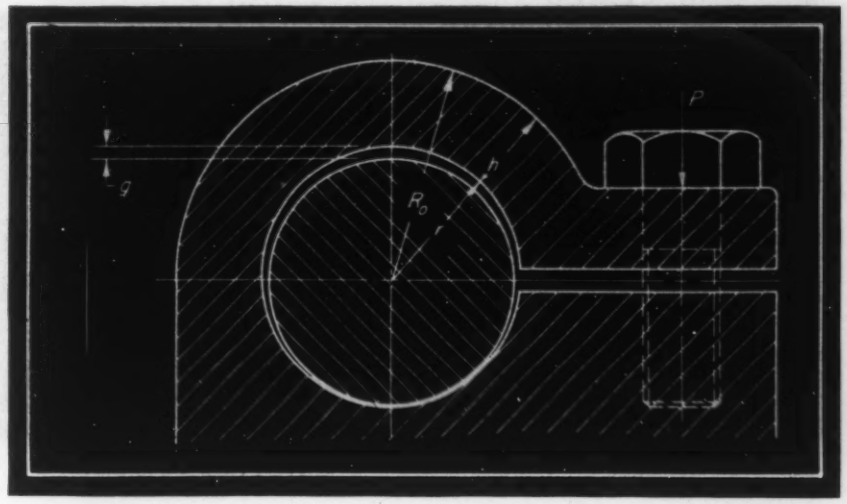
Finish	Without Augmenting Coating (Hours)	With Augmenting Coating (Hours)
Phosphate:		
Oiled	1	24
With rust preventative	2	36
Painted	no requirements	150
Oxide Black; Alkali Oxidizing:		
Oiled	½	2
Lacquered	½	16

* Abstracted from U. S. Army Specification 57-O-2C. Test time allows no evidence of corrosion.

Predictions based on accelerated laboratory tests are sometimes in a class with those based on polls in the political field. However, properly-designed tests and wisely-interpreted results can and often do teach those concerned the types of failure to be expected with a certain type of finish under specific types of environmental conditions. Alternative finishes can be placed in order of merit, for example, with respect to their resistance to water soaking, high humidity, ultraviolet radiation or saline fog, TABLE II. The best of a group can thus be chosen for the type of environment in which the article is expected to serve. Then, after sufficient data have been accumulated on serviceability this valuable experience may be applied to designing finishes for similar parts in the future.

"I guess it's a tough problem . . . . they've been in conference all morning!"

Fig. 1—Simple round-bar clamp, showing unclamped clearance greatly exaggerated



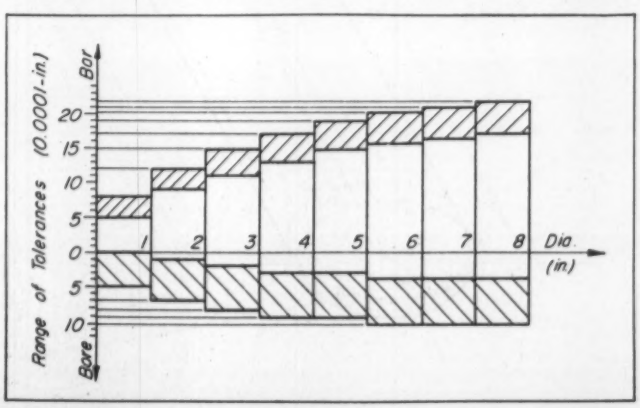
HOW TO DESIGN Round-Bar Clamps

By Louis Dodge
Cincinnati

EFFECTIVENESS of a clamp, that is, its power to hold, depends mainly on the accuracy of the fit of bore and bar, the provision and maintenance of sufficient clamping power, the proper proportioning of vital parts, and the surface condition of bar. Breakage of clamps is mainly due to excessive clearance between bore and bar and the resultant high stresses when clamping is attempted.

When this happens, the suggestion to increase the thickness of the clamp in order to obtain additional strength is not infrequently advanced even by machine designers. The fallacy of this is quite apparent when one recalls that for a given deflection of a bar the bending stress of the outer fibers increases in proportion to their distance from the neutral axis. Therefore, one important consideration of design is to make the flexible part of the clamp as thin as is consistent with the load the closed clamp has to support, and yet sturdy enough to be acceptable for manufacturing reasons. When additional strength is required a lengthening of the clamp may in many cases meet the requirements of heavier loads.

Fig. 2—Limits for sliding fits as a function of bar diameter



To make a clamp sufficiently flexible yet satisfying the demands of ruggedness for ordinary working practice, the depth of hub h, *Fig.* 1, can be made relatively thinner with increasing diameter of bar. This condition can be expressed by the following equations, which are valid for bar diameters up to 5 inches. For bar diameters larger than 5 inches, h remains constant at $h = r/2$.

$$h = r(1 - 0.2r) \quad \ldots\ldots (1)$$

$$R_o = r + h = 2r - 0.2r^2 \quad \ldots\ldots (2)$$

The resulting values for bar diameters up to 8 inches

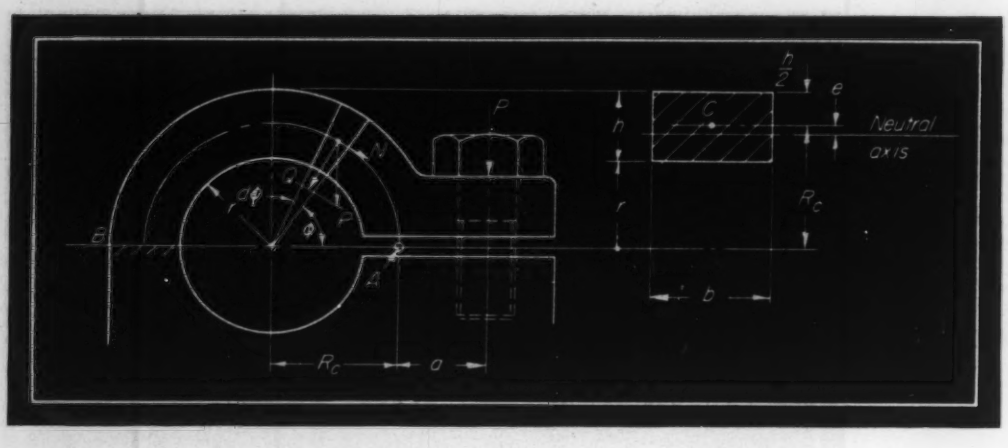


Fig. 3—Upper half of clamp, showing how stress and deflection analyses consider the curved beam effect

are given in TABLE I which appears on Page 119.

The following analysis is based on cast iron. For steel and other materials modifications can be made in accordance with the appropriate strength and other properties.

It can readily be seen that, the function of the clamp being to grasp firmly a sliding or turning round bar, the power to hold is augmented by making bore and bar tolerances as small as a sliding fit permits. The limits for sliding fits for bar diameters up to 8 inches, shown in *Fig.* 2, are approximately in accordance with manufacturers' working practice. The upper limits represent the maximum possible tolerance or gap between bore and bar, which is equivalent to the deflection the flexible half of the clamp has to sustain before clamping action becomes effective.

Initial force required to deflect the flexible half of the clamp can be calculated from the known theory of bending stresses in curved beams. As is well known, the stress distribution in a curved beam is not directly proportional to the distance of the fibers from the centroid, and the neutral axis is displaced toward the center of curvature an amount *e, Fig.* 3, which can be calculated from the following approximate equation[1] for beams with rectangular cross section:

$$e \approx \frac{h^2}{12\,R_c} \qquad (3)$$

where R_c = radius to centroid = $r + h/2$. The values of h and R_c, previously calculated, are used in deriving the corresponding values for e, which have been tabulated in TABLE I.

For a more exact calculation of the distance e from the neutral axis the following equation can be used.

$$e = R_c \frac{m}{1+m}$$

where

$$m = \frac{1}{3}\left(\frac{h}{2R_c}\right)^2 + \frac{1}{5}\left(\frac{h}{2R_c}\right)^4 + \frac{1}{7}\left(\frac{h}{2R_c}\right)^6 + \cdots\cdots$$

1. References are tabulated at end of article.

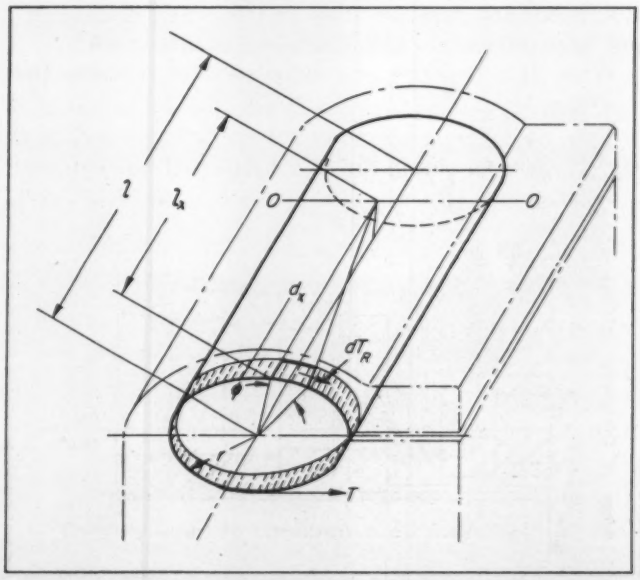
Referring to *Fig.* 3, the upper half of the clamp can be considered a curved beam rigidly supported at point B and subjected to a vertical force P. Therefore any element of the curved beam is subjected to a bending moment M, a shearing force Q, and a tensile force N. The work required to close the clamp, i.e., to deflect the upper half an amount sufficient to eliminate the gap g, is transformed into potential energy of strain, providing this strain remains within the elastic limit of the material. This elastic strain energy in bending for a beam of rectangular cross section can be found from the following expression:

$$u_1 = \int_0^{\pi} \frac{M^2 ds}{2AEeR_c} \qquad (4)$$

where M = bending moment; ds = elongation of unit section of beam; A = area of cross section; E = modulus of elasticity; e = distance of neutral axis from the centroid; and R_c = radius to centroid.

For any cross section the bending moment is

Fig. 4—Notation used in analyzing the clamping resistance to twisting of the bar



$$M = \left[a + R_c (1 - \cos \phi) \right]$$

According to the theorem of Castigliano the deflection δ at point A can be found by taking the derivative of the strain energy with respect to P. Since $ds = R_c d\phi$

$$\delta_1 = \frac{du_1}{dP} = \int_0^\pi \frac{M^2}{AEep} d\phi = \int_0^\pi \frac{\left[Pa + PR_c (1 - \cos\phi) \right]^2}{AEeP} d\phi$$

$$= \frac{Pa^2}{AEe} \int_0^\pi d\phi + \frac{2 PaR_c}{AEe} \int_0^\pi (1 - \cos\phi)\, d\phi +$$

$$\frac{PR_c^2}{AEe} \int_0^\pi (1 - \cos\phi)^2 \, d\phi$$

$$\delta_1 = \frac{P\pi}{AEe} \left[(a + R_c)^2 + \frac{R_c^2}{2} \right] \quad \ldots\ldots (5)$$

Similarly, the elastic strain energy of tension produced by the force N in the curved beam is

$$u_2 = \int_0^\pi \frac{N^2 ds}{2AE}$$

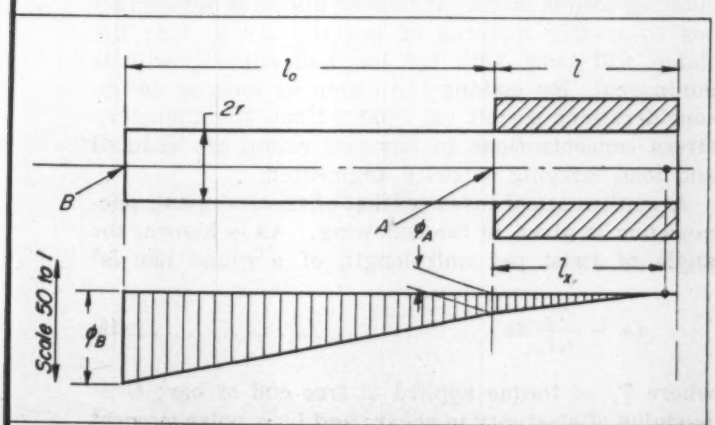
where $N = P \cos\phi$, and

$$\delta_2 = \frac{du_2}{dP} = \int_0^\pi \frac{N^2 R_c}{AEP} d\phi = \frac{PR_c}{AE} \int_0^\pi \cos^2\phi \, d\phi$$

$$= \frac{PR_c}{AE} \left[\frac{\phi}{2} + \frac{1}{2} \sin\phi \cos\phi \right]_0^\pi = \frac{P\pi R_c}{2AE} \quad \ldots\ldots (6)$$

The amount of energy produced by the shearing force Q is

Fig. 5—Relative twist of bar outside and inside clamp



$$u_3 = \int_0^\pi \frac{KQ^2 ds}{2AG}$$

where K = intensity of shear stress; G = modulus of elasticity in shear; $Q = P\sin\phi$; and

$$\delta_3 = \frac{du_3}{dP} = \int_0^\pi \frac{KQ^2 R_c}{AGP} d\phi = \frac{P\pi KR_c}{2AG} \quad \ldots\ldots (7)$$

By adding the single deflections, the total vertical deflection at point A is obtained:

$$\delta_T = \delta_1 + \delta_2 + \delta_3$$

$$\delta_T = \frac{P\pi}{AEe} \left[(a + R_c)^2 + \frac{R_c^2}{2} \right] + \frac{P\pi R_c}{2AE} + \frac{P\pi KR_c}{2AG}$$

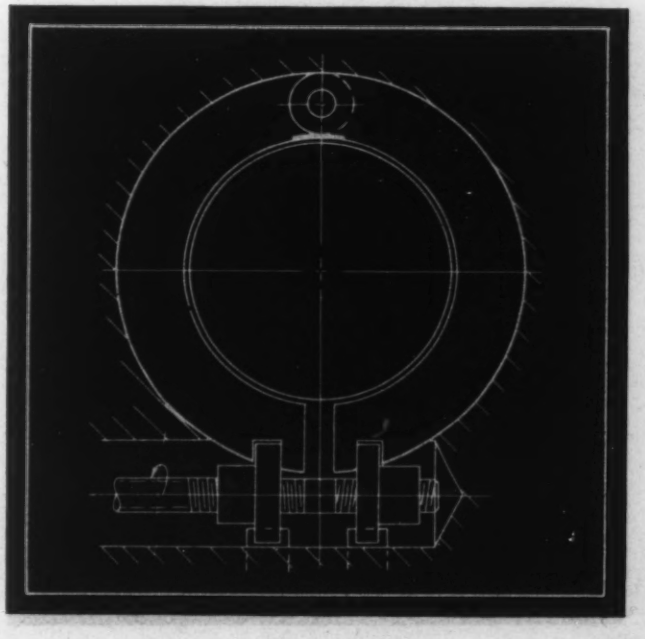
$$\delta_T = \frac{P\pi}{AE} \left\{ \frac{\left[(a + R_c)^2 + \frac{R_c^2}{2} \right]}{e} + \frac{R_c}{2} \left(1 + \frac{KE}{G} \right) \right\} \quad (8)$$

For a rectangular cross section, K can be taken 50 per cent greater than the mean intensity of shear, i.e., $K = 1.5$. Letting $E/G = 14 \times 10^6/5.5 \times 10^6 = 2.55$,

$$\delta_T = \frac{P\pi}{AE} \left\{ \frac{\left[(a + R_c)^2 + \frac{R_c^2}{2} \right]}{e} + 2.4\, R_c \right\} \quad \ldots\ldots (9)$$

and

Fig. 6—Floating clamp of the hinged type which requires no force for initial closing



$$\frac{1}{P} = \frac{\pi}{AE\delta_T}\left\{\frac{\left[(a + R_c)^2 + \frac{R_c^2}{2}\right]}{e} + 2.4\ R_c\right\} \quad \ldots\ldots (10)$$

The deflection δ_T at point A can be taken with sufficient accuracy as twice the maximum allowance g between bore and bar. The limits taken from *Fig.* 2 have been used in computating the deflections δ_T for corresponding bar diameters and added to TABLE I. Then Equation 10 can be employed to calculate the force required to close the gap g of the clamp. Computing the areas A of clamps having the respective radii for a uniform width of 1 inch, the force P required for surface contact has been calculated, the findings being shown in the last column of TABLE I. The average value of P for a clamp 1 inch wide is 74.3 lb. The small variation, considering the wide diversity of bar sizes, is a rather unexpected finding.

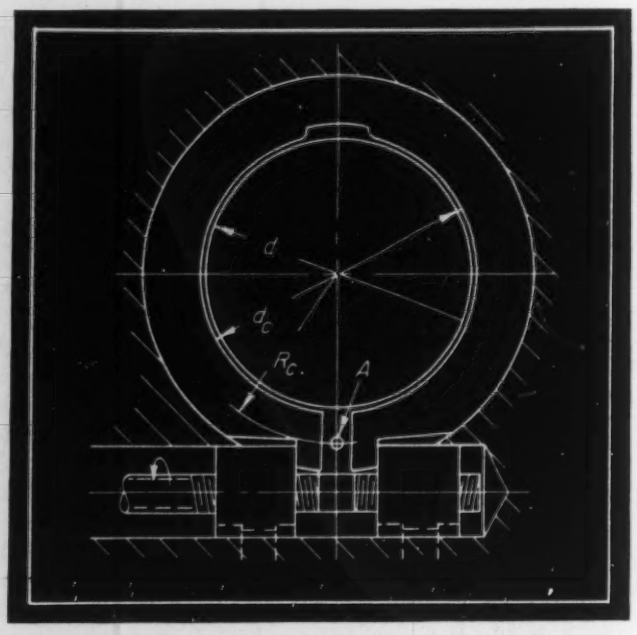
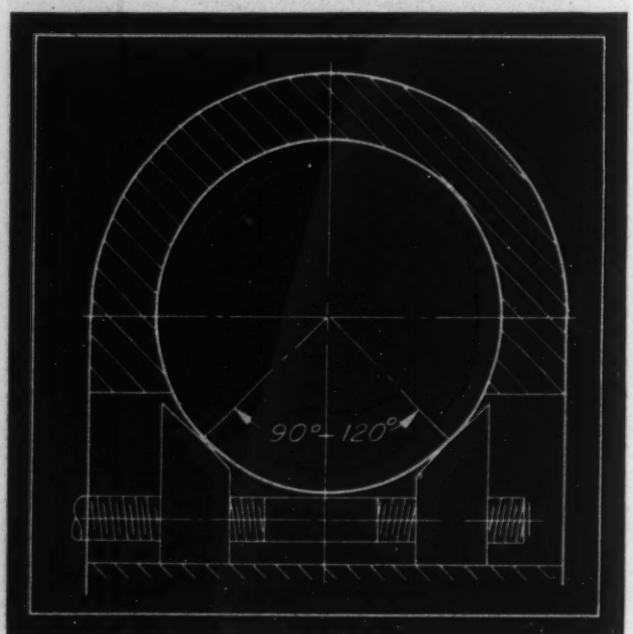


Fig. 7—Above—Floating clamp of the integral type which, like the hinged type, exerts no net force on bar

Fig. 8—Below—Double-wedge clamp. Wedges usually are hard bronze or cast iron to minimize abrasion of bar



Obviously, the bolt tension must be in excess of this initial force P if the clamping is to be effective. Assuming that the load distribution over the round bar is uniform when the clamp is closed, i.e., that no further deflection takes place at point A except as a result of the elongation caused by the force N, then the clamping force L is twice the effective bolt tension, and the bar is held by a force

$$L = 2(S - P) \quad \ldots\ldots (11)$$

where S = total bolt tension.

The force H required to displace the round bar longitudinally in a clamp of high rigidity is approximately

$$H = 2L\mu = 4S_e\mu \quad \ldots\ldots (12)$$

where μ = friction coefficient, repose; and S_e = $S - P$ = effective bolt tension.

Torque T required to produce angular displacement of the bar in a clamp of high rigidity is approximately

$$T = 2L\mu r = 4S_e\mu r \quad \ldots\ldots (13)$$

For a clamp of low rigidity, i.e., when the distribution of contact pressure over the bar is uniform, the torque T can be found from the known expression for rope friction over a pulley:

$$T = S_e\,(e^{\mu\alpha} - 1)\,r \quad \ldots\ldots (14)$$

where e = 2.718; and α = included contact angle (180° to 360°). Evidently the magnitude of T, in most practical cases, will lie somewhere between the two extreme conditions expressed by Equations 13 and 14.

It is commonly assumed that no slipping or twisting of the bar takes place in the clamp itself, which holds firmly. As has been pointed out elsewhere[2] and disclosed through experimental tests, a bar subject to torque will twist inside a tightly holding clamp. The twisting and slipping will be most marked at the side of applied torque. This phenomenon is important when considering clamps designed to sustain oscillating torque loads. It follows that it is advantageous to specify material of low rigidity so that the clamp will twist with the bar and slipping will be minimized. By making the clamp as long as design considerations permit (at least 2 times the diameter) stress concentrations in bar and clamp are reduced and load-carrying capacity augmented.

A mathematical investigation of the foregoing phenomenon is given in the following. As is known, the angle of twist per unit length of a round bar is[3]

$$d\phi = \frac{T_o}{GI_p}\,dx \quad \ldots\ldots (15)$$

where T_o = torque applied at free end of bar; G = modulus of elasticity in shear; and I_p = polar moment

of inertia. Likewise, denoting the negative torque of resistance per unit length of clamp by dT_R and assuming that the transfer of dT_R takes place uniformly over the contact surface between bore and bar in either direction, then the negative angle of twist of the bar is (*Fig.* 4):

$$-d\phi_R = -\frac{dT_R\,dx}{2GI_p} \quad \ldots\ldots(16)$$

and the angle of twist of the bar within the clamp is

$$\phi = \int_0^{l_x} \frac{T_o}{GI_p}\,dx - \int_0^{T_o}\int_0^{l_x} \frac{dT_R\,dx}{2GI_p} \quad \ldots\ldots(17)$$

The limits of integration can be found from the condition of equilibrium which must prevail along the section l_x of the bar where the negative torque of resistance equals the torque applied at the free end of the bar. The state of strain and the corresponding twist of the bar will diminish toward and reach the vanishing point at line *O-O*.

TABLE I

Dimensions of Round-Bar Clamps

Diameter	h (approx.)	R_o (approx.)	e	a	δ_T (max.)	P (max.)
(in.)	(in.)	(in.)	(in.)	(in.)	(in.)	(lb)
½	¼	½	0.015	⅜	0.0026	70
¾	⅜	¾	0.022	½	0.0026	80
1	7/16	11/16	0.024	9/16	0.0038	90
1½	⅝	1⅝	0.032	¾	0.0038	86
2	11/16	1 11/16	0.040	11/16	0.0046	95
2½	11/16	2 9/16	0.045	1⅛	0.0046	88
3	1 1/16	2 7/16	0.047	1¼	0.0052	88
3½	1⅛	2⅞	0.046	1⅜	0.0052	75
4	1 3/16	3 3/16	0.046	1½	0.0056	70
5	1¼	3¾	0.044	1¾	0.0060	55
6	1½	4½	0.052	2	0.0062	55
7	1¾	5¼	0.061	2¼	0.0064	58
8	2	6	0.068	2⅝	0.0065	56

Recalling Equation 14,

$$T_R = T_o = \frac{S_e\,(e^{\mu\alpha} - 1)\,rl_x}{l}$$

where l = length of clamp. Also

$$l_x = \frac{lT_o}{S_e\,(e^{\mu\alpha} - 1)r} \quad \ldots\ldots(18)$$

Substituting these limits in Equation 17 and integrating,

$$\phi = \frac{T_o l_x}{2GI_p} = \frac{T_o{}^2 l}{S_e\,(e^{\mu\alpha} - 1)\,r2GI_p} \quad \ldots\ldots(19)$$

Similarly, recalling Equation 13,

$$l_x = \frac{lT_o}{4S_e\mu r} \quad \ldots\ldots(20)$$

and

$$\phi = \frac{T_o l_x}{2GI_p} = \frac{T_o{}^2 l}{4S_e\mu r2GI_p} \quad \ldots\ldots(21)$$

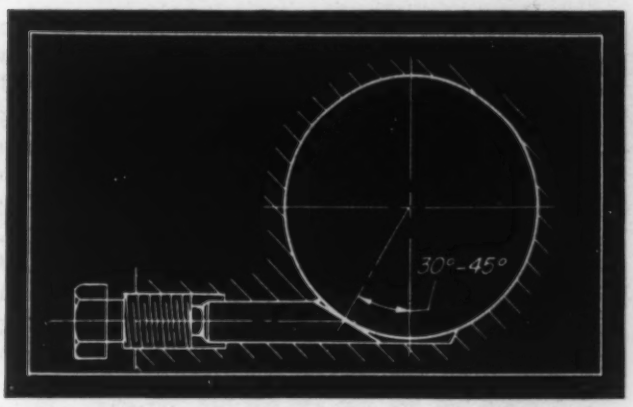
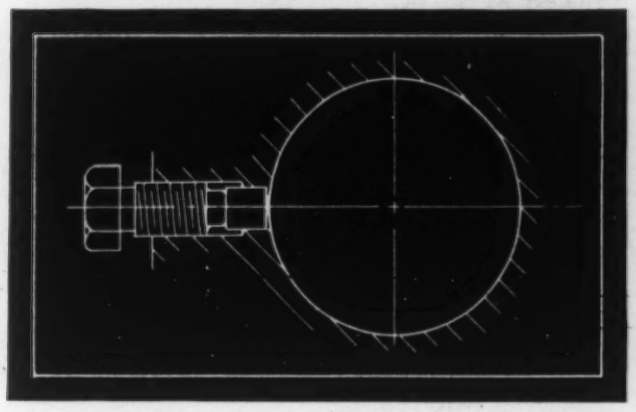


Fig. 9—Above—Single-wedge clamp. Like the double-wedge clamp, this type is suitable when torque is small and slight dislocation of bar is inconsequential

Fig. 10—Below—Shoe-type clamp, which is suitable only for temporary locking and small torque



Equations 19 and 21 represent the magnitude of slippage of bar at point *A*, in radians.

It is obvious that such a simplified analytical method of investigation should be supplemented by experimental methods when a more exact solution of practical cases is required. Surface condition of the bar and the distribution of contact pressures are factors of importance difficult to establish.

An example will show the magnitude of slippage within a tight clamp. Referring to *Fig.* 5, let T_o = 3500 lb-in.; $G = 12 \times 10^6$ psi; $r = 1$ in.; $I_p = 1.57$ in.^{4}; $\mu = 0.25$; $\alpha = 250°$; $e^{\mu\alpha} = 3$; $l = 5$ in.; $l_o = 10$ in.; and $S_e = 3000$ lb. Then from Equation 18,

$$l_x = \frac{5 \times 3500}{3000(3 - 1) \times 1} = 2.91 \text{ in.}$$

$$\phi_A = \frac{2.91 \times 3500}{2 \times 12 \times 10^6 \times 1.57} = 0.00027\text{-radian}$$

$$= 55.7 \text{ sec}$$

From Equation 15,

$$\phi_B = \frac{3500 \times 10}{12 \times 10^6 \times 1.57} = 0.00186\text{-radian}$$

$$= 6 \text{ min } 23.7 \text{ sec}$$

FLOATING CLAMPS: A floating clamp consists of

a concentric ring which in the released state fits snugly in a housing bore and maintains a minimum clearance between clamp bore and shaft. In the closed state the clamp bore engages a shaft or bar having the same diameter as the bore. This type of clamp is especially suitable for designs which permit no deflection of the bar in bending when clamping is performed. It can be of the hinged or integral type, *Figs.* 6 and 7. Its effective torque load can be found from Equation 13 or 14. No initial force is required to close the hinged type clamp, provided no spring pressure has been employed to separate the clamp halves.

Concerning the integral type, the initial pressure required to close the clamp can be found by employing a simplified form of Equation 9. Assuming that there is no strain present in the released state of clamp and that the deflection δ_T of one half of the clamp at point A is equal to the difference between d and d_c. Then

$$\delta_T = \frac{P_\pi}{AE}\left(\frac{3R_c^2}{2e} + 2.4\,R_c\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots (22)$$

Also, when neglecting the second term in the parenthesis as being small,

$$\delta_T = \frac{3P_\pi R_c^2}{2AEe} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (23)$$

The pressure required to close the clamp is

$$P = \frac{2\delta_T AEe}{3\pi R_c^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (24)$$

WEDGE-TYPE CLAMPS such as shown in *Figs.* 8 and 9 are employed when a dislocation of the bar is inconsequential and when the torque transmitted is relatively small. The wedges are usually made of hard bronze or cast iron in order to prevent abrasion of the surface of the bar.

SHOE-TYPE CLAMPS: The shoe type clamp, *Fig.* 10, is perhaps the simplest one used in machine design for unimportant bars when temporary locking either by screw or thumb screw is sufficient.

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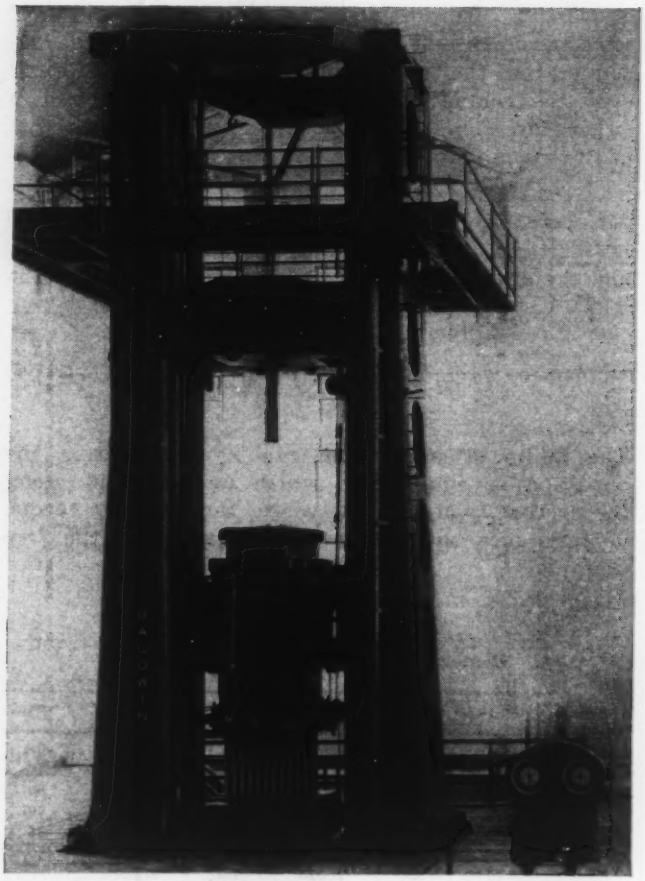
1. S. Timoshenko—*Strength of Materials,* D. Van Nostrand Co. Inc., New York, Part II, Page 428.
2. W. Trinks, "Things that are commonly wrong in text books on machine design," *Journal of Engineering Education,* March, 1933.
3. S. Timoshenko—*Strength of Materials,* D. Van Nostrand Co., Inc., New York, Part I, Page 264.

Tests Aircraft Structures

LARGEST TESTING machine in the world, of five million pounds capacity, was recently demonstrated at the aeronautical structures laboratory of the Philadelphia Naval Base. Manufactured by the Baldwin Locomotive Works, the new machine will be used primarily for testing full-sized aircraft structural members such as cylindrical elements for fuselages, carrying members of wings, and box beams.



Stiffness of full-sized panel sections may be more accurately determined than has been previously possible. Specimens up to 30-ft high, 10-ft wide between columns and 50-ft long can be accommodated and tested in tension, compression or flexure.

Built to Navy specifications, the machine incorporates several design features that tend to minimize horizontal deflection under off-center loading conditions. Crossed flex plate stays, adjustable guides for the sensitive crosshead, and flaring of the columns at the base limit the deflection under horizontal loading to about one-third of the allowable amount.

Hydraulic pressure on the loading cylinder is supplied by a 3000 psi capacity pump driven by a 75-hp motor. The sensitive crosshead is positioned by a 50-hp motor rotating the two 55-ft screws by means of drive gears under the bedplate. The load measuring system, accurate within half of one per cent, consists of an Emery cell and a Tate-Emery indicator with two indicating dials. The Emery cell and indicator are connected by flexible tubing for transmission of the hydraulic pressure to the Bourdon tube in the indicator.

One of the testing machine accessories is an elevator consisting of a platform surrounding the machine and powered by a 15-hp motor under the bedplate. A constant rate of load increase may be obtained by use of the load-rate pacing disk and its associated controls. A similar strain-rate pacing disk will hold the strain rate constant if desired. The machine is also equipped with an automatic recording apparatus for making load-elongation records.

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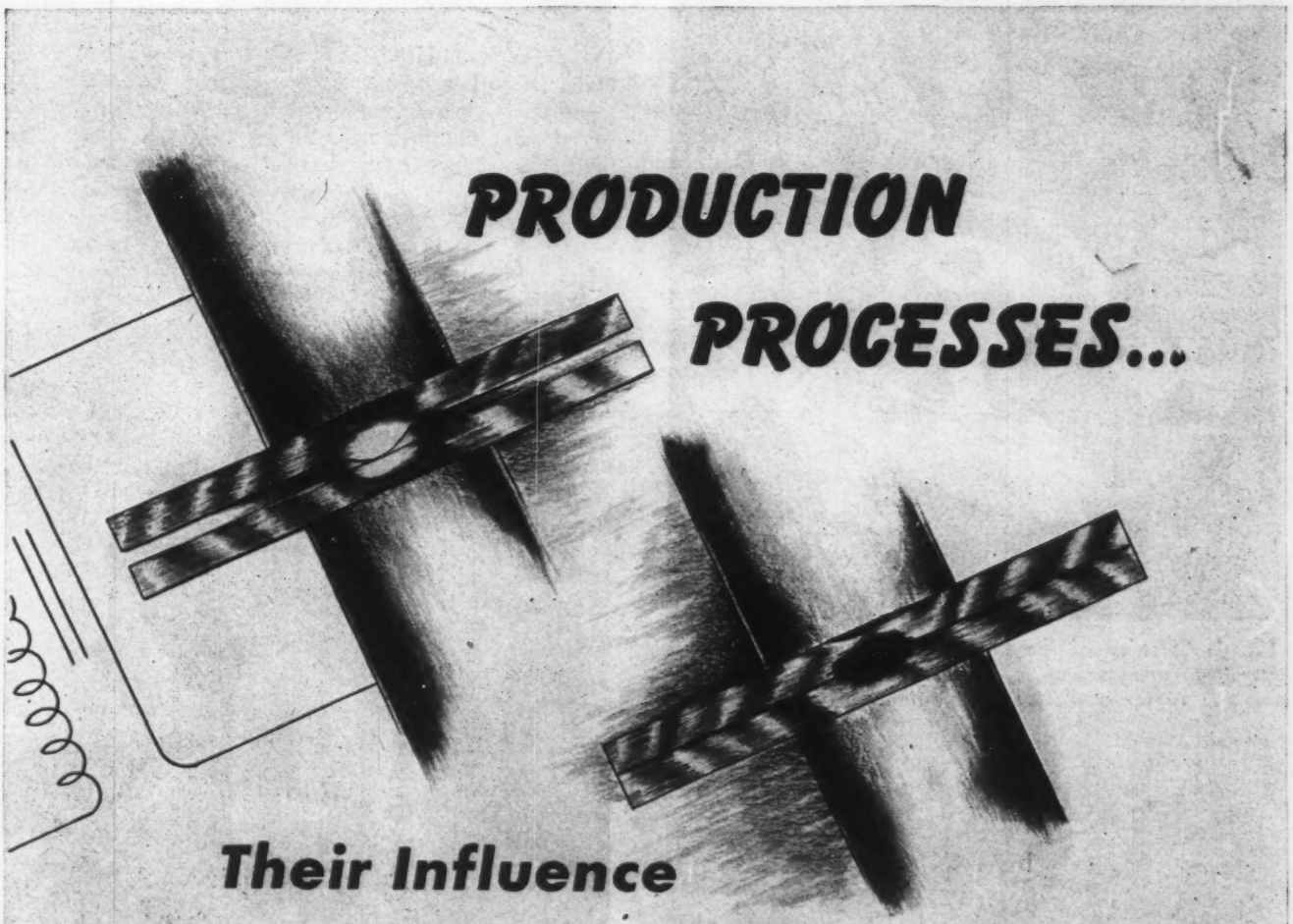


PRODUCTION PROCESSES...

Their Influence On Design

By Roger W. Bolz
Associate Editor, Machine Design

Part XL–Projection Welding

AN OUTGROWTH of simple resistance spot welding, the method termed projection welding has a definite place in the production picture. Most important, perhaps is the fact that with projection welding, two or more parts can be permanently joined most nearly as dictated by design; the major limitations of spot welding are not present.

With projection welding, current flow and electrical heating to create individual weld spots or buttons are concentrated at specific points by means of projections on the parts rather than by the machine electrodes. By means of these projections on one or both parts to be welded, relative location of weld spots on the parts can be accurately determined beforehand thus eliminating any possible error in manufacture, *Fig.* 1. Much faster than spot welding, this method allows the simultaneous creation of multiple welds; as few as one or as many as

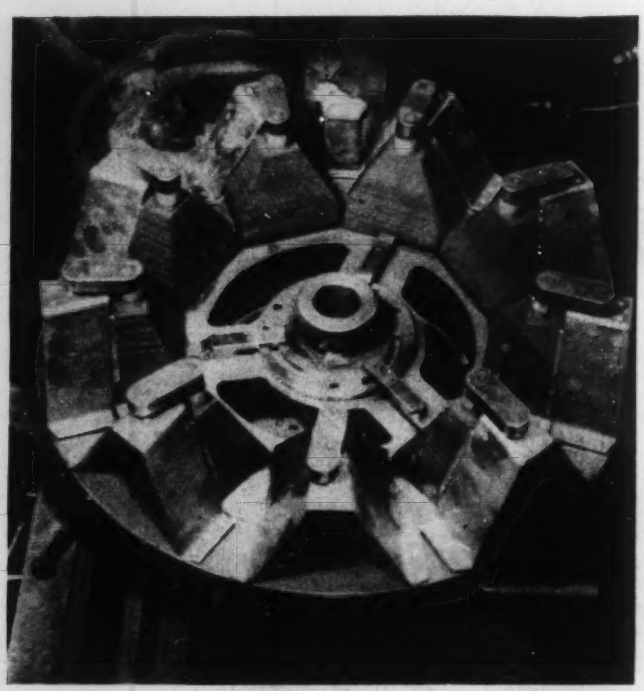


Fig. 1—Close-up of the projection welding of fan units for large electric motors. Six welds are made at each index and 25 fans per hour produced

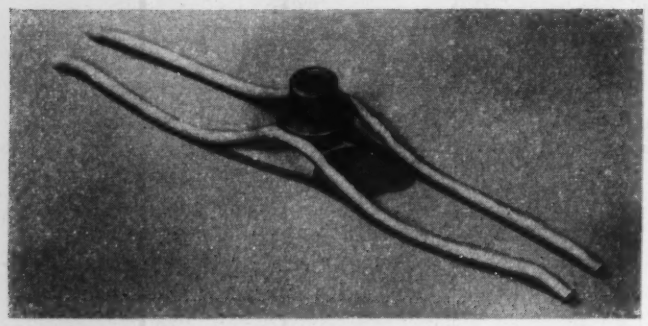


Fig. 2—Machined collar piece and wire forms, projection welded into one unit

thirty or more spots can be made at a single impulse, depending upon the power available. Also, a large number of welds can be accurately placed in a limited area without experiencing the shunting difficulties found in spot welding.

Ordinarily, projection welding requires two to three times the electrode pressure of spot welding and an average operation requires up to twice the current. It does, however, make possible the resistance welding of parts which are either impossible or impractical to spot weld conventionally. Not only is projection welding adaptable to flat or regular parts of sheet, plate, tubing, etc., as is spot welding; it also can be used to join irregular shapes and thick parts such as forgings, heavy stampings, complex machined pieces, and even wire, *Fig.* 2.

Projection welding electrodes or, in some cases, dies, normally have a large-area contact with the parts to be welded. This allows introduction of high currents without injuring the part surface and results in long electrode die life.

PROJECTION WELDING MACHINES. Because greater

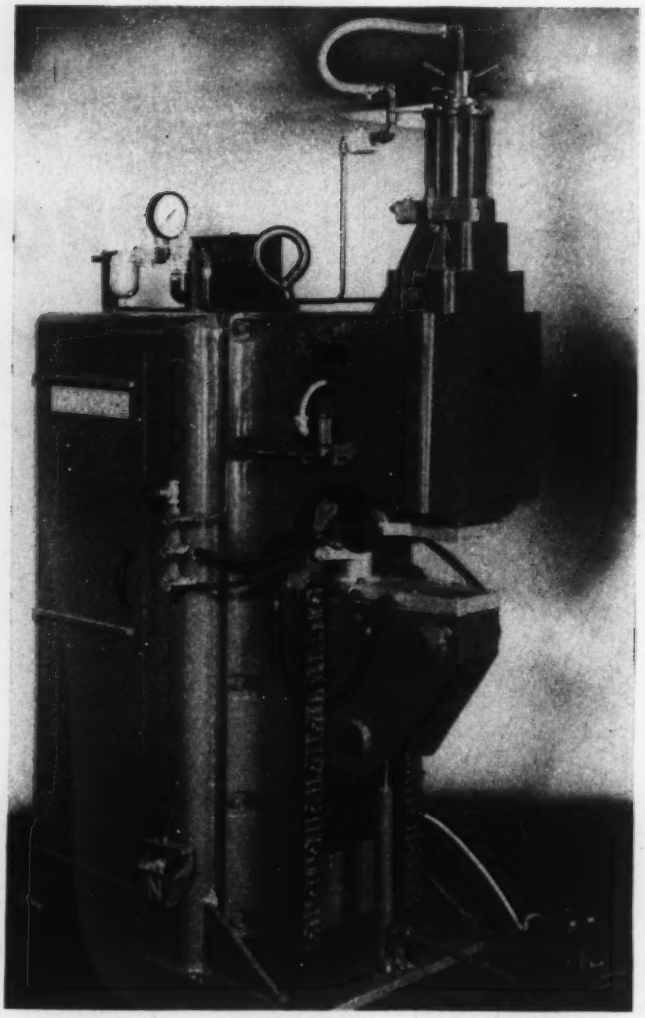


Fig. 3—Typical press type projection welder

pressure is required in projection welding than in spot welding, considerably more powerful machines are used. Owing to the need for the heads to come together smoothly, uniformly and parallel, press type welders constructed to afford greater rigidity in the arms are used, *Fig.* 3. Low inertia movement of the welding head in desirable to assure steady application of pressure as the projections collapse during the weld cycle. The lower electrode holder is usually made adjustable to accommodate a range of part sizes and in some cases is designed to accommodate special high-production parts, *Fig.* 4. Complex assemblies of parts are often handled in totally special-purpose machines, *Fig.* 5.

Standard projection welders conform to the general specifications outlined by the Resistance Welder Manufacturers Association, TABLE I. Electrode or platen area for No. 1 machines is 6 by 6 inches; for No. 2, 7 by 7 inches; for No. 3, 9 by 9 inches; and for No. 4, 12 by 12 inches, both upper and lower. Spacing between platens is adjustable on all sizes and can be varied from 4 inches to 12 inches with the upper platen in the down position. Ram stroke for the upper platen is 2 inches for No. 1 machine, 3 inches for No. 2, and 4 inches for Nos. 3 and 4. Ram drives may be pneumatic, hydraulic or mechanical.

DESIGN: Careful analysis of the design of parts to be projection welded as well as cognizance of the various factors relating to proper projection size and shape can result in highly satisfactory, economical parts, *Fig.* 6. Theoretically, projections may be of an almost unlimited variety of forms. In practical application, however, certain types have been found most satisfactory and economical and hence are recommended for use wherever possible.

In projection design it is always desirable to have a point or line contact from which the weld may grow. Ordinarily the weld grows from the center outward and consequently the most satisfactory projection is the round or button type. To obtain the vitally needed heat balance—equal distribution of heat between the two parts being welded—it is often necessary to change to rib or elongated projections on extremely heavy sections.

Ordinarily for welding sheet ranging in thickness from 24 to 13-gage, the button or spherical projection is used. Standards for dimensioning such projections are shown in *Fig.* 7. Stock ranging from 12 to 5-gage in thickness is most satisfactorily welded by means of the conical type projections shown in *Fig.* 8. Under no circumstances should partially sheared plugs or semipunchings be used inasmuch as such projections ordinarily will not withstand the initial pressure prior to application of the current without collapse.

As a rule, for welding fairly heavy pieces to very thin sheet under 24-gage the annular upset as produced by a prick punch will serve as a suitable proj-

Fig. 4—Air-operated press type projection welder for making annular welds on high-production parts

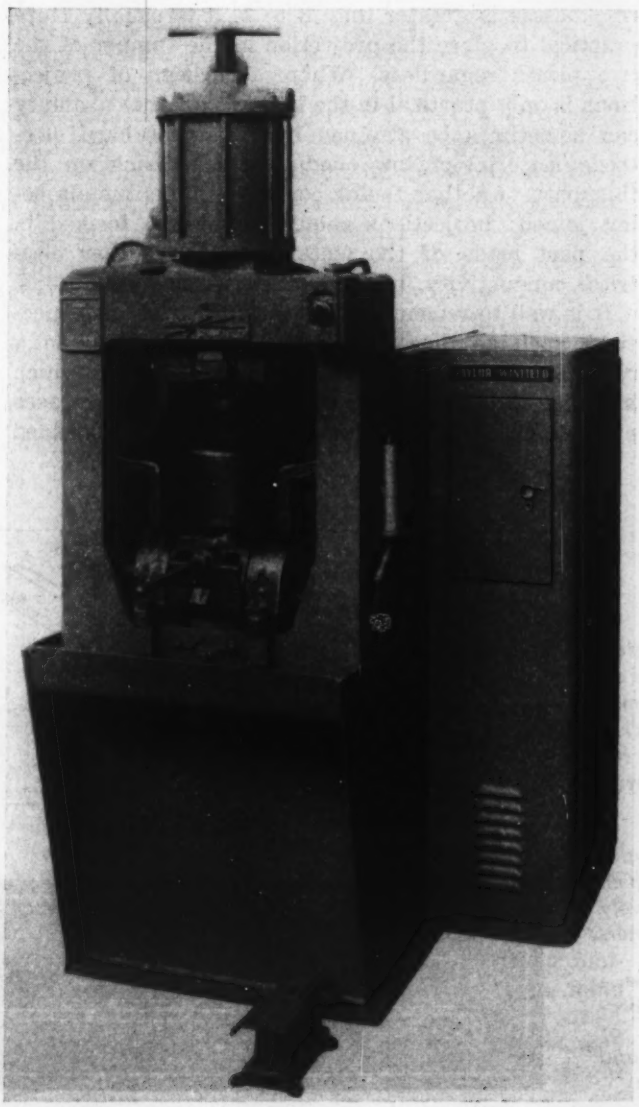


Fig. 5—Special projection welder for welding typewriter body assemblies

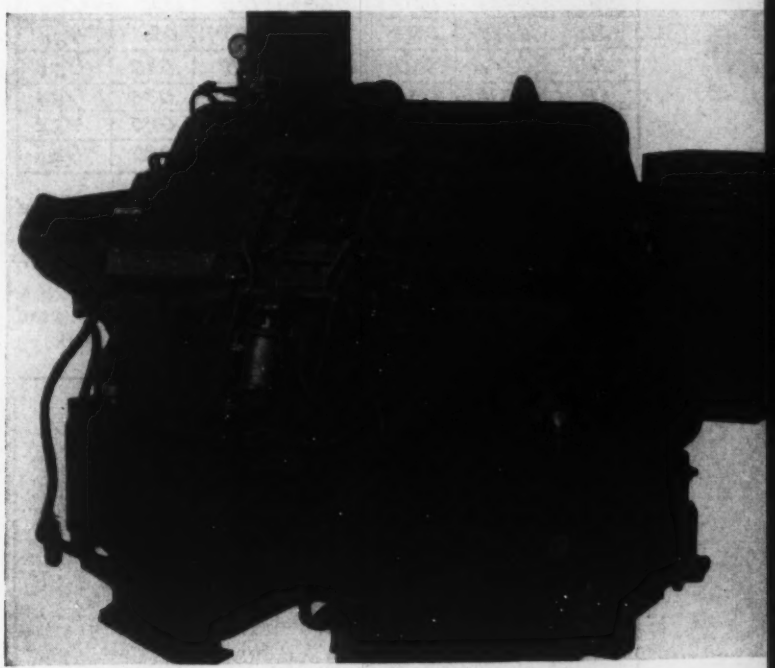
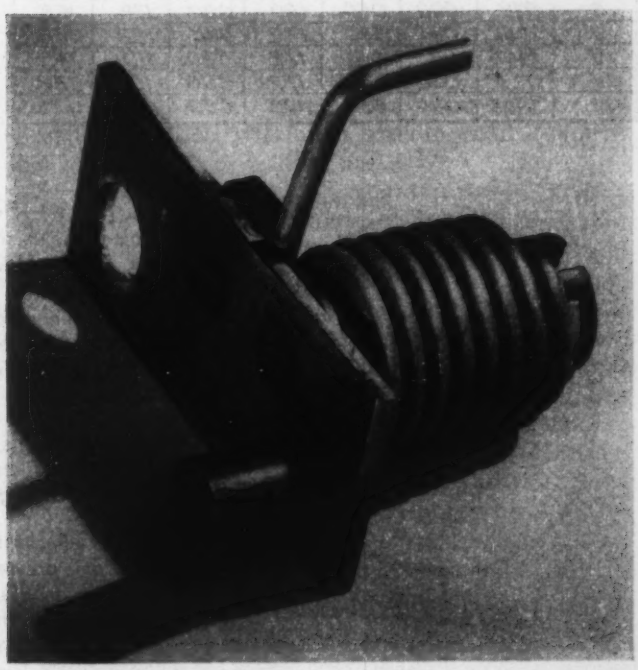
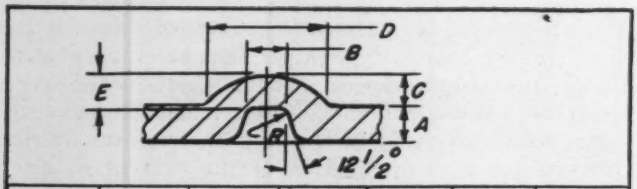


Fig. 6—Door interlock, with two pins and a boss to be welded to ⅛-inch steel strip. Redesign for projection welding saved 35 per cent over plug welding formerly used

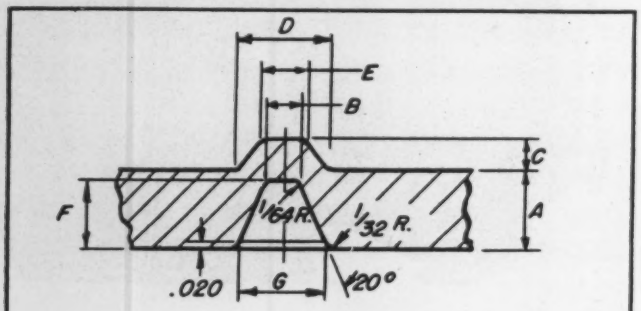




GAGE	A	B	C	D	E	R
13	.0937	.075	.050	.180	.065	1/64
14	.0781	.075	.050	.180	.065	1/64
15	.0703	.075	.045	.172	.055	1/64
16	.0625	.060	.045	.172	.050	1/64
17	.0562	.055	.040	.156	.045	1/64
18	.050	.050	.040	.156	.040	1/64
19	.0437	.050	.040	.125	.035	1/64
20	.0375	.050	.035	.125	.035	1/64
21	.0344	.050	.030	.125	.030	1/64
22	.0312	.050	.030	.125	.030	1/64
23	.0281	.050	.025	.109	.025	1/64
24	.025	.050	.025	.109	.025	1/64

Fig. 7—Above—Design of button projections usually used for embossing or stamping into 13 to 24-gage stock

Fig. 8—Below—Design of cone projections usually used for embossing or stamping into 5 to 12-gage stock



GAGE	A	B	C	D	E	F	G
5	.218	.080	.075	.210	.100	.200	.220
6	.2031	.080	.070	.203	.094	.182	.206
7	.1875	.080	.070	.203	.094	.166	.185
8	.1718	.080	.060	.190	.080	.138	.166
9	.1562	.080	.060	.172	.080	.122	.155
10	.1406	.080	.060	.172	.080	.110	.145
11	.125	.080	.055	.172	.080	.100	.138
12	.1093	.080	.055	.172	.080	.090	.131

ection. Actually, though projection welding of sheets under 24-gage has been done, the use of projections formed in sheet under 0.015-inch thick is not recommended because of insufficient strength for the operation.

When projections are made on formed pieces, the mating contact surface for which is not flat, it is usually desirable to use elongated projections, *Fig.* 9. Elongated projections can also be used to provide for welding corners of sheet, *Fig.* 10*a*. In some cases the sheet ends can be sheared to leave projections of suitable shape, *Fig.* 10*b*.

Projections for gas and watertight joints are normally made with ring or annular embossed projections, *Fig.* 11. Annular projections can also be used advantageously for attaching large circular parts or bosses as well as a variety of other similar designs.

Proper Heat Balance Imperative

To assure creation of proper fusion temperature at precisely the same instant in both of two parts being welded, it is desirable that projections for parts of unequal thickness be made in the heavier piece. A projection in the thin piece would burn off before the heavy piece was brought up to fusion temperature. It has been found, however, that where the ratio of thicknesses is greater than 3 to 1, it is usually more practical to place the projection in the thinner of the two pieces regardless. Where formation of projections is only practical in the lighter part, heat balance can sometimes be attained by means of hard electrode material of low conductivity to back up the thin part. Another factor concerns unlike metals being joined; projections should always be formed in the part made of the metal with the higher electrical conductivity, barring other unusual conditions.

It is well to remember that the formation of projections such as those in *Figs.* 7 and 8 results in a reduction in area through the welded portion which in some designs may be undesirable. In many cases projections can be machined, cast, forged or headed

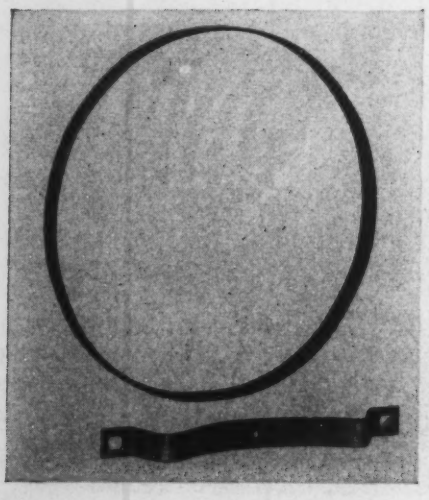


Fig. 9—Left—Elongated projections as shown on this refrigeration machine ring and bracket are recommended for welding pieces with curved surfaces

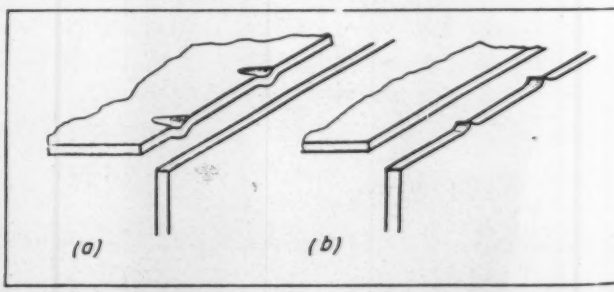


Fig. 10 — Right — Types of projections which can be used effectively for end welding corners

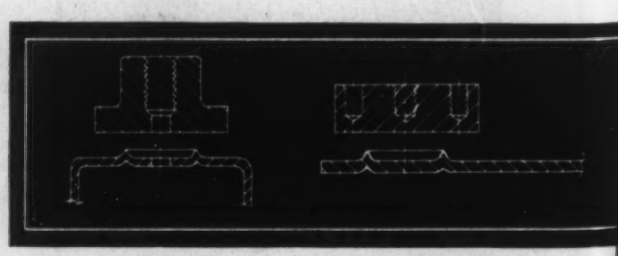


Fig. 11—Right Below — Annular pressed projections are used for watertight welds and attaching bosses

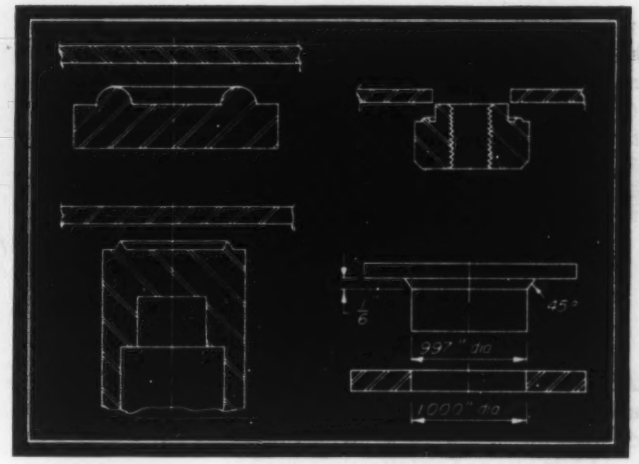


Fig. 12 — Left — Some common annular types of integral projection designs which can be machined or formed

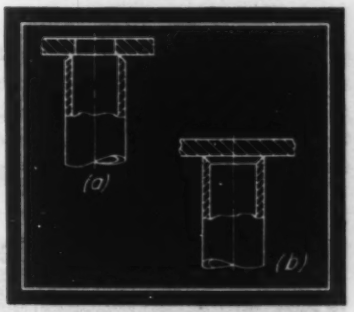


Fig. 13—Right Above —Bevels are used in welding tubular sections to flats. The external bevel (a) results in minimum flash inside and (b) minimum flash outside

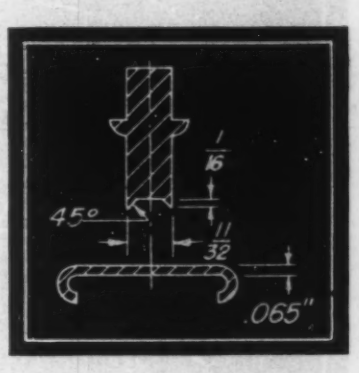


Fig. 14—Right — Ring projection welded assembly showing machined projection. Very little flash results

during production of the part to avoid the stamped projection. Integral projections, as these are called, can be of an almost unlimited variety. Machined projections may be of the annular, pyramid, elongated or spherical types, or of special design. Some common annular types are shown in *Fig.* 12. Special annular projections or bevel forms are used to weld tubing, the type in *Fig.* 13*a* being preferred where minimum flash is desirable inside. Where tubing is to be welded to a flat surface and minimum flash is desirable outside, the bevel is usually placed on the inside, *Fig.* 13*b*. Solid parts are similarly handled, *Fig.* 14. Where parts are not turned the pyramid or modified pyramid projections can be frequently used, *Fig.* 15, as can the elongated types.

On accurate, heavy assemblies in which no flash is desired between the mating parts after welding, a special type of coined projection has been used. Typical projection designs for ¼-inch and ½-inch plate are shown in *Fig.* 16. The volume of the depression surrounding the projection is made approximately 70 per cent of the volume of the spherical portion above the surface of the plate.

A variety of projections — annular, spherical, elongated, pyramidal, dome and multiple—can be

TABLE I

Specifications For Standard Projection Welders

(Press Type)

Size No.	Rating (kva)	Throat Depth (in.)
1	30–50–75	12–18–30
2	100–150	12–18–30
4	300–400–500	12–18–30
3	150–250	12–18–30

produced by coining, forging or heading. Typical varieties are shown in *Fig.* 17 which contains a representative group of projection welding fasteners.

For welding to sheet ⅛-inch and under, multiple projections provide optimum results with minimum current, pressure and time. Three projections located radially as far from the part axis as possible and equally spaced offer the best results. In using multiple projections, however, it is well to keep in mind the problems encountered in assuring good contact on all projections with groups over three. Obviously with up to 3 projections, slight variations in height

Fig. 15—Modified pyramid projections milled into ⅞ by 2 by 4-inch steel block for a strapping tool

would have no deleterious effect on the operation. With more than three, however, projections must be held to very close tolerances on height or difficulty is experienced in obtaining simultaneous collapse. Such conditions are well to avoid.

Where multiple welds are utilized, distance between projections should not be less than two times the projection diameter (*D, Figs.* 7 and 8). Overlap of straight welded portions should also be at least equal to 2*D* or preferably greater, and so designed that the weld button is centered in the overlap.

Electrode contact on the parts should extend at least 5 times the projection diameter in all directions from the weld to assure uniform heat distribution. To simplify the welding of contoured parts, therefore, the area immediately surrounding a projection should be kept free as possible from excessively complex interferences or contours.

MATERIALS: It is possible to projection weld all the metals or combinations of metals which can be resistance welded (See Part XXXVIII—Spot Weld-

ing, November, 1948 issue). Some materials, however, are difficult or impossible to upset in welding and some require preheat and postheat treatments rendering their use in projection welding unsatisfactory. Again, some metals are not strong enough to support a projection. Brasses in general and also copper are undesirable for this reason. Aluminum has only been found successful to a limited extent; mainly with extruded parts. Very thin steel sheet (under 24-gage) is ordinarily more easily spot welded than projection welded.

Most satisfactory materials for projection welding are, generally:

Low-Carbon Steel (Carbon 0.20 max.)
Naval Brass
Monel
Stainless Steels (Types 309, 310, 316, 317, 321, 347, and 349. Nonhardenable, carbon 0.15 max.)

Any of these materials can be used together, dissimilar combinations being readily weldable. Projections, of course, should be made in the metal with the highest conductivity.

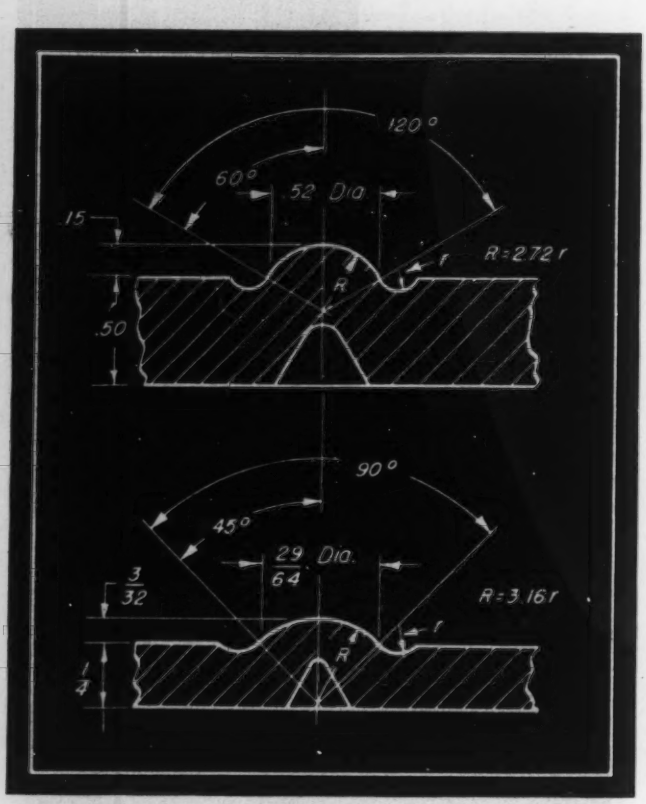
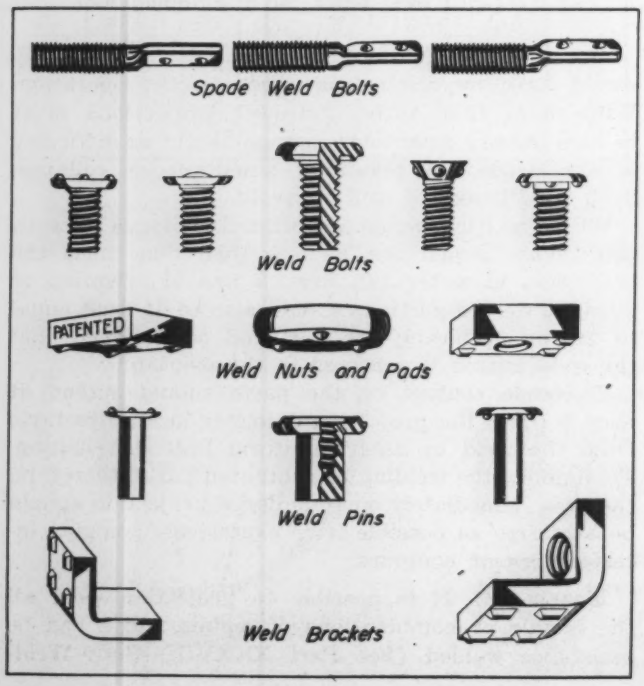


Fig. 16—Above—Special type of projection used for heavy plate where no flash and close fit of parts is desired

Fig. 17—Below—Typical projections normally produced by forging are exemplified in these standard projection welding fasteners



Optimum Surface Bright Finished

Optimum welds on all materials are obtained with parts bright finished; that is, clean surfaces without scale, foreign materials or plating. Where assemblies are too large or complex for plating after welding, parts can be plated separately prior to welding. Zinc plating (electrogalvanizing) is the best and does not materially affect the welding operation. As in spot or seam welding, such finishes as Parkerizing, black oil finish, etc., should not be used inasmuch as they are poor electrical conductors.

TOLERANCES: Owing to the fact that all welds in projection welding are made simultaneously, the process lends itself to fixturizing. Too, many parts can be welded accurately by means of only the positioning afforded by the electrode platens. Assembly tolerances obtained are directly dependent upon the fixtures used and to assure minimum part cost, widest possible tolerances should be allowed. Accurate relative location of parts in assembly can also be assured by means of semipunchings in one part which fit into mating holes in the other. Such details can usually be produced simultaneously with the projections.

In materials up to and including 0.050-inch thickness, the projection diameter *D*, *Figs.* 7 and 8, is usually held to a tolerance of plus or minus 0.003-inch and in heavier materials, to plus or minus 0.007-inch. The height *C* is normally held to a tolerance of plus or minus 0.002-inch in gages up to and including 0.050-inch while plus or minus 0.005-inch is allowed on heavier gages.

Collaboration of the following organizations in the preparation of this article is acknowledged with much appreciation:

Federal Machine & Welder Co. (*Figs.* 5 and 14) ..... Warren, Ohio
General Electric Co. (*Figs.* 1, 2 and 9) Schenectady, N. Y.
National Electric Welding Machines Co. (*Fig.* 3) ..... Bay City, Mich.
Ohio Nut & Bolt Co. (*Fig.* 17) ..... Berea, Ohio
Resistance Welder Manufacturers Association (*Figs.* 7 and 8) ..... Philadelphia, Pa.
Swift Electric Welder Co. (*Fig.* 16) ..... Detroit, Mich.
Taylor-Winfield Corp. (*Fig.* 4) ..... Warren, Ohio
Westinghouse Electric Corp. (*Fig.* 6) East Pittsburgh, Pa.

Unified Screw-Thread Standards

SIGNIFICANCE of the unified screw-thread pact signed last November by Britain, Canada and the United States needs no emphasis. The military advantages which spurred the agreement, as well as the commercial benefits of interchangeability in international trade, are obvious. To the machine designer who will have to live with the new standard, however, the changes involved will soon become a matter of intimate practical concern. It is the purpose of this article to show how the unified standards will differ from the present national standard and to point out the principles which will govern the establishment of new allowances and tolerances for the various grades.

Proportions of the Unified Thread

BASIC THREAD: Basic elements of the unified thread are shown in *Fig.* 1. The 60-degree thread angle is that used in the American National thread, developed originally by Sellers in 1864. For the British it represents a major change from the 55-degree Whitworth thread which they have used since 1845.

Crests and roots were all truncated in the American National and all rounded in the Whitworth. The

Fig. 1—Basic proportions of the unified form of thread, which apply to the "maximum metal" condition

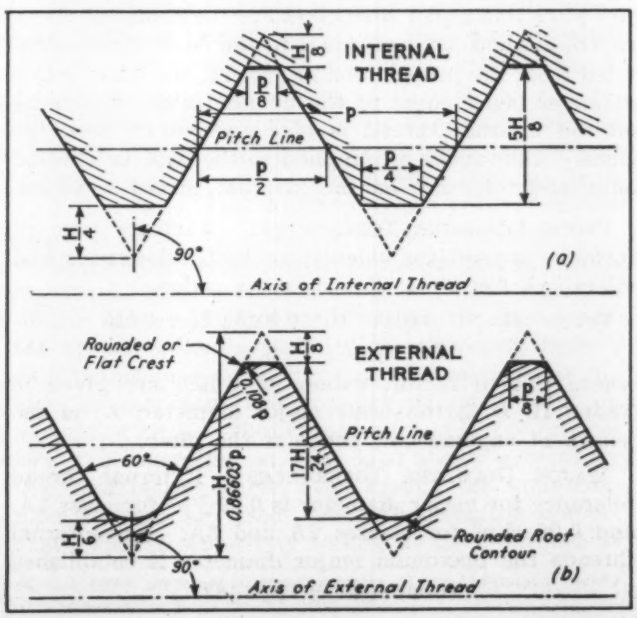


TABLE I—Unified System Sizes and Thread Series

Nominal Size or Basic Major Diameter	Number of Threads per Inch					
	Coarse	Fine	Extra fine	8-thread	12-thread	16-thread
0*(0.060)	..	80	..	..	..	..
1*(0.073)	64	72	..	..	..	..
2*(0.086)	56	64	..	..	..	..
3*(0.099)	48	56	..	..	..	..
4*(0.112)	40	48	..	..	..	..
5*(0.125)	40	44	..	..	..	..
6*(0.138)	32	40	..	..	..	..
8*(0.164)	32	36	..	..	..	..
10*(0.190)	24	32	..	..	..	..
12*(0.216)	24	28	32	..	..	..
1/4	20	28	32	..	..	..
5/16	18	24	32	..	..	..
3/8	16	24	32	..	..	..
7/16	14	20	28	..	..	..
1/2	12†	20	28	..	12	..
9/16	12	18	24	..	12	..
5/8	11	18	24	..	12	..
11/16	..	..	24	..	12	..
3/4	10	16	20	..	12	16
13/16	..	..	20	..	12	16
7/8	9	14	20	..	12	16
15/16	..	..	20	..	12	16
1	8	12	20	8	12	16
1 1/16	..	..	18	..	12	16
1 1/8	7	12	18	8	12	16
1 3/16	..	..	18	..	12	16
1 1/4	7	12	18	8	12	16
1 5/16	..	..	18	..	12	16
1 3/8	6	12	18	8	12	16
1 7/16	..	..	18	..	12	16
1 1/2	6	12	18	8	12	16
1 9/16	..	..	18	..	..	16
1 5/8	..	..	18	8	12	16
1 11/16	..	..	18	..	..	16
1 3/4	5	..	16	8	12	16
1 13/16	..	..	..	..	..	16
1 7/8	..	..	..	8	12	16
1 15/16	..	..	..	..	..	16
2	4 1/2	..	16	8	12	16
2 1/16	..	..	..	..	..	16
2 1/8	..	..	..	8	12	16
2 3/16	..	..	..	..	..	16
2 1/4	4 1/2	..	..	8	12	16
2 5/16	..	..	..	..	..	16
2 3/8	..	..	..	..	12	16
2 7/16	..	..	..	..	..	16
2 1/2	4	..	..	8	12	16
2 5/8	..	..	..	..	12	16
2 3/4	..	..	..	8	12	16
2 7/8	..	..	..	..	12	16
3	4	..	..	8	12	16
3 1/8	..	..	..	..	12	16
3 1/4	4	..	..	8	12	16
3 3/8	..	..	..	..	12	16
3 1/2	4	..	..	8	12	16
3 5/8	..	..	..	..	12	16
3 3/4	4	..	..	8	12	16
3 7/8	..	..	..	..	12	16
4	4	..	..	8	12	16
4 1/4	..	..	..	8	12	16
4 1/2	..	..	..	8	12	16
4 3/4	..	..	..	8	12	16
5	..	..	..	8	12	16
5 1/4	..	..	..	8	12	16
5 1/2	..	..	..	8	12	16
5 3/4	..	..	..	8	12	16
6	..	..	..	8	12	16

* American standard, not part of the unified system.
† A 13-thread screw appears in the American Standard but is not part of the unified system.

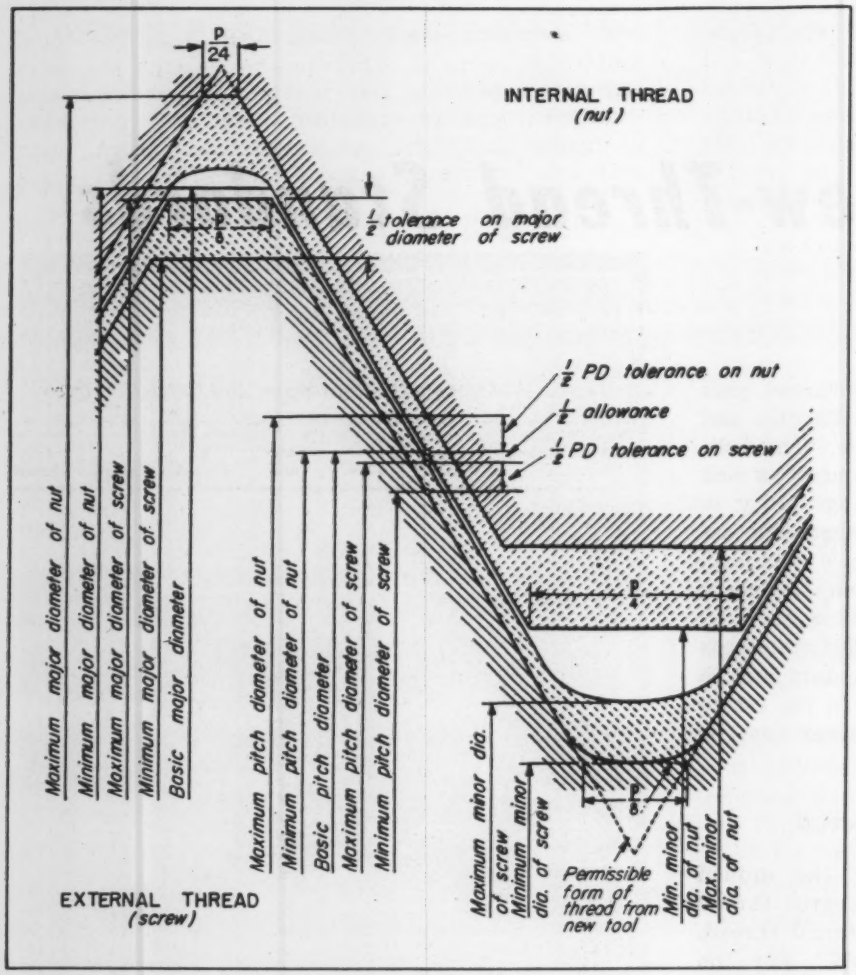

INTERNAL THREAD
(nut)
EXTERNAL THREAD
(screw)
½ tolerance on major diameter of screw
½ PD tolerance on nut
½ allowance
½ PD tolerance on screw
Maximum major diameter of nut
Minimum major diameter of nut
Maximum major diameter of screw
Minimum major diameter of screw
Basic major diameter
Maximum pitch diameter of nut
Minimum pitch diameter of nut
Basic pitch diameter
Maximum pitch diameter of screw
Minimum pitch diameter of screw
Maximum minor dia. of screw
Minimum minor dia. of screw
Permissible form of thread from new tool
Min. minor dia. of nut
Max. minor dia. of nut

Fig. 2—Pictorial representation of the critical dimensions which must be controlled in the manufacture of screw thread components, showing the tolerance ranges

new standard emphasizes the desirability of a rounded root contour for the external or bolt thread, but permits a flat root, as formerly, when using unworn tools, *Fig.* 2. Crest of the internal thread may be flat or rounded, while the internal or nut threads have flat crests, and flat roots which may become rounded as tools wear.

DIAMETERS AND PITCHES: Sizes agreed upon and the threads per inch in each series are, with a few exceptions, the same as in the present American National standard, TABLE I. In the coarse thread series the ½-inch Unified thread will have 12 threads per inch, like the Whitworth, instead of 13 as in the National. However, the ½-inch 13-thread size will appear in standards published in the U. S., although not part of the unified system. In the fine thread series the unified 1-inch size will have 12 threads per inch instead of 14 as in the National. Several new sizes have been added to the extra-fine thread series (formerly the SAE extra-fine series) and to the 16-thread series. The numbered sizes are not part of the unified system but are included in the American standards.

CLASSIFICATION OF FITS: Three classes of screw-thread fit have been established for general use. They are designated 1A, 2A and 3A for external threads and 1B, 2B and 3B for internal threads.

Classes 2A and 2B are the recognized standards for normal production of screws, bolts and nuts and are suitable for a wide range of other applications. The combination of classes 1A and 1B provides a fit suitable for threaded parts where quick and easy assembly is necessary, even when the threads are bruised or dirty, as in ordnance and certain special applications. Classes 3A and 3B are suitable for applications requiring close fit and accuracy of lead and angle of thread. Such fits are obtainable only by the use of high quality production equipment supported by efficient gaging and inspection.

TABLE II—Values of Factor C

Class	C for Allowance	C for Tolerance
1A	0.450	1.500
1B	....	1.950
2A	0.300	1.000
2B	....	1.300
3A	0.000	0.750
3B	....	0.975

A wide variety of fits may be obtained by specifying the proper combination of classes. For example, an external thread made to class 2A limits can be used with tapped holes made to classes 1B, 2B or 3B depending upon the application.

Classes 2 and 3 in the National coarse and fine thread series are being retained in the American standard but are not part of the unified system.

LIMITS: For the internal thread the *minimum* major, pitch and minor diameters are the same for classes 1B, 2B and 3B, and equal to the *basic* sizes calculated from the proportions in *Fig.* 1*a*, the basic major diameter being equal to the nominal size. Tolerance on the internal thread is *plus* and varies with the class. Allowances are applied to the external thread only, and tolerance on the external thread is *minus*.

PITCH DIAMETER TOLERANCES: A single type of formula is used for calculating both allowances and tolerances for pitch diameters, as follows:

$$\text{Tol. or all.} = C(0.0015\sqrt[3]{D} + 0.0015\sqrt{L_e} + 0.015\sqrt[3]{p^2}) \quad \ldots\ldots (1)$$

where C is a factor, values of which are given in TABLE II, D is the basic major diameter, L_e is the length of engagement, and p is the pitch.

MAJOR DIAMETER TOLERANCES: External thread tolerance for major diameter is $0.09\sqrt[3]{p^2}$ for class 1A, and $0.06\sqrt[3]{p^2}$ for classes 2A and 3A. For internal threads the maximum major diameter is established

(*Continued on Page* 182)

Process Control Valves

How linear and equal-percentage valves should be selected on basis of linearity of process under control

By N. B. Nichols and J. G. Ziegler
Director of Research *Sales Engineer*
Taylor Instrument Companies
Rochester, N. Y.

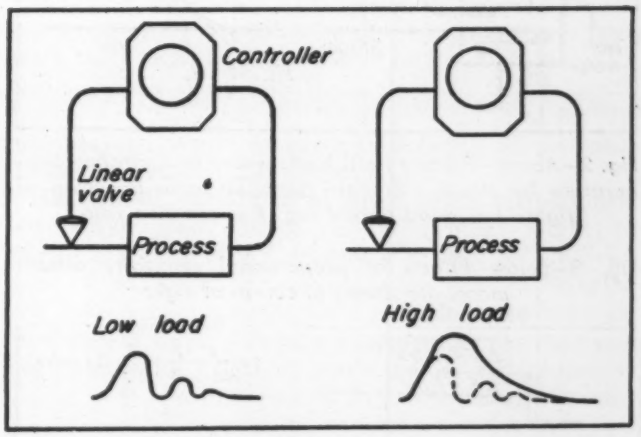


Fig. 1—Curves indicate influence of load magnitude on stability in a control circuit using a linear valve

FROM a construction standpoint, the simplest control valve is probably the single or double seated "beveled-disk" type, sometimes called a quick-opening or poppet valve. It was probably the first type of valve used with automatic control devices since it is essentially a globe valve with a sliding stem instead of the usual threaded type operated by a handwheel. It requires less lift than ported or shaped plug valves to reach a reasonable maximum capacity for passing the controlled medium.

But the beveled-disk valve has fallen into disfavor because of its linear flow-lift characteristic; the area of its effective opening increases in almost direct proportion to the lift of the disk from the seat. When such valves are used on certain processes, a nonlinearity appears; control results are not equally good under different "load" conditions, load generally being expressed in terms of the valve opening necessary to maintain the measured variable at the required value. If, on these processes, the controller is adjusted to give optimum control under a low-load condition, that is with a small valve opening, it is found that excessive stability is realized when the process is operating under high-load conditions.

Effect of this nonlinearity is shown in *Fig.* 1. A proportional plus automatic-reset controller operates a linear valve and the control under low-load conditions shows optimum stability in recovering from a small disturbance or load change, indicating that the controller responses are properly adjusted. But on the right, a similar disturbance applied to the process when it is operating at high load shows a recovery curve that is too stable, even though the same controller settings are used. By increasing the proportional-response sensitivity setting of the controller at this load, the dotted recovery curve could be obtained, but this setting would be excessive when the process returned to the low-load condition and would result in sustained oscillation or hunting. So the sensitivity could not be increased above the value required at the more difficult load condition. Unless the instrument is readjusted for each load, the control results will not be as good as they could be at any but the low-load condition.

In the control circuit of *Fig.* 1, the valve is linear, as is the controller response, but the process is nonlinear. There are two obvious ways to correct the circuit even without altering the nonlinear process. It is conceivable that another controller measuring the load could be installed and used to adjust the setting of the first so that the sensitivity would be automatically increased with increasing load. Commercially, this method has not been used to any extent because it requires a more elaborate control mechanism than is generally justified. The same result can be obtained by leaving the controller linear but altering the shape of the valve disk so that a given increase in lift at large openings produces more increase in flow than the same lift at low openings. This has the same effect as changing the controller sensitivity which is only a measure of the amount of valve movement resulting from a given pen movement, and valve movement only affects the process as it changes the flow of controlled medium to the process.

The purpose, then, of using a valve with characteristics other than those of a simple beveled-disk is an attempt to cancel the nonlinearity of a process by means of a nonlinear valve. If successfully done, the control circuit should have equal stability at all load conditions.

It is not practical to design a valve individually for

From a paper presented at the Conference of the Instrument Society of America, September 13-17, in Philadelphia.

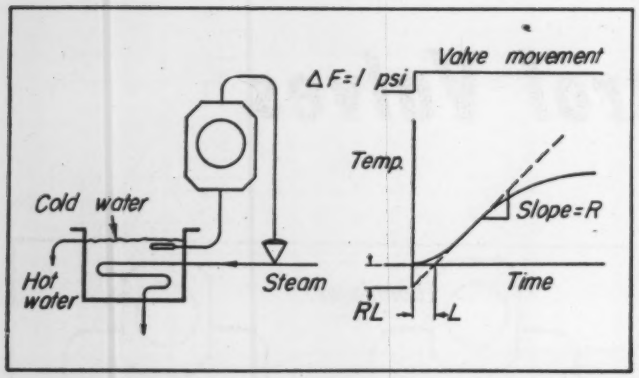
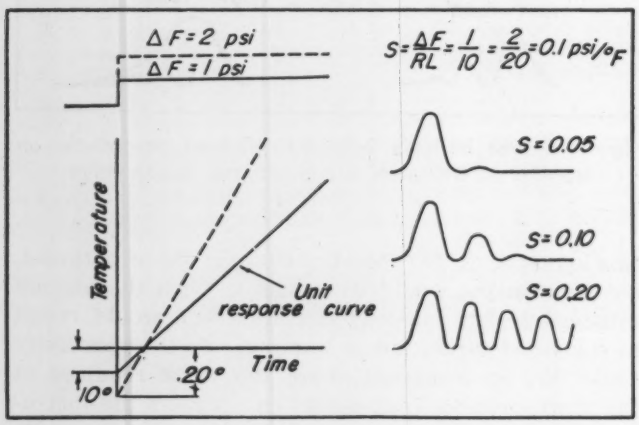


Fig. 2—Above—Process (left) heats water to controlled temperature by steam. Process response curve is shown at right; L is dead period lag, R is reaction rate

Fig. 3—Below—Effects of proportional sensitivity adjustments are shown in curves at right



each process because of the large variety of process nonlinearities. Instead, valve manufacturers have attempted to standardize on a so-called "equal percentage" valve, which theoretically compensates for one of the more common process nonlinearities. This characteristic is approached by a variety of valve plugs such as the various V-ported and V-notched types and the shaped plugs such as ratio, throttle and parabolic types.

Approximated Curve Used in Analysis

One of the simplest yet most useful methods of process analysis is that of approximating the "process response curve" or reaction curve and using two of its most important dimensions for predicting the controller settings and the control results obtainable.

If, when a process is under stable control with the valve in exactly the right position to satisfy the process demand and hold the instrument pen at the correct value, the valve is removed from the dictates of the instrument and suddenly moved to a different opening, and held there, the new flow of controlled medium will cause the pen to draw a "process response curve". Consider the process of *Fig.* 2, in which water flows through a tank and is heated by a steam coil to a controlled temperature. Enough steam is flowing through the partially open valve to maintain the tank temperature at a constant value. Suddenly the valve is opened slightly by making a sustained change of 1 psi on the diaphragm motor. More steam flows to the heating coil and the water temperature rises; the controller pan traces an S-shaped process response curve as shown. The approximation consists in drawing a straight line tangent to the point of inflection of the curve and saying that the process is adequately represented by the simpler curve consisting of a dead-period lag, L, and a "reaction rate", R. The fact that the actual process response curve levels out eventually at a new value (self regulation while the straight line does not) is of secondary importance in the control analysis and can be disregarded. Thus, it can be said that the process shown in *Fig.* 2 is characterized by an effective dead-period lag, L minutes, and that for a 1 psi change in pressure to the diaphragm motor the pen deviates at a maximum rate of R inches per minute.

If the sloped line of the approximated process response curve is dropped back until it intersects the temperature axis, the intercept is the product of R and L or the distance which the pen travels in a time equal to L. This intercept is indicative of the controller sensitivity required for stable control. If the instrument is set so that it gives a valve movement equal to ΔF for the pen movement of RL degrees, stable control will result. In other words, the sensitivity will be equal to $\Delta F/RL$. Putting numbers on these quantities, suppose L is one minute, R is ten de-

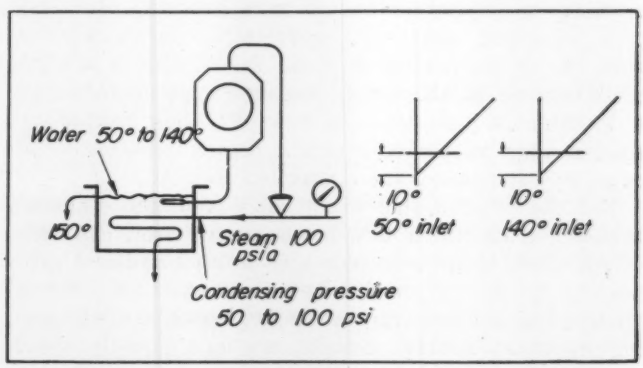
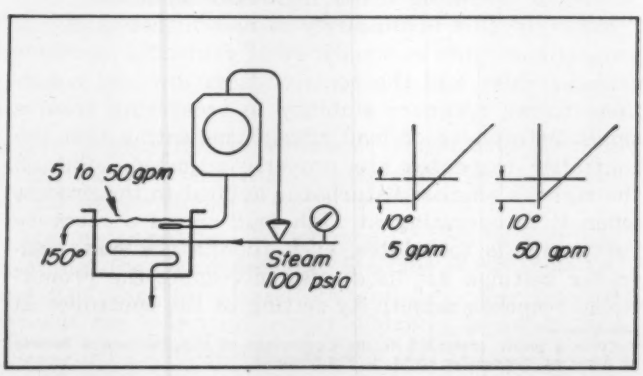


Fig. 4—Above—Process in which inlet-water temperature varies. Unit response curves (right) are identical for both temperature extremes

Fig. 5—Below—Process in which inlet-water flow rate varies. As in process of Fig. 4, the unit response curves (right) are identical for both extremes



grees per minute and the valve change initiating the response curve is 1 psi. The *RL* intercept would be ten degrees so the controller sensitivity would be set to give 1 psi change in output for each ten degrees of pen movement, or 0.1 psi per degree.

The response curve approximation for the process of *Fig.* 2 is shown in *Fig.* 3, following 1 psi change in valve position. Dotted on the same figure is a similar curve that would result from a 2 psi change in valve position; it evidences the same lag, but twice the increase in steam flow causes the temperature to change twice as fast. The *RL* intercept of 20 degrees for a 2 psi change in valve position still indicates that the same controller sensitivity of 0.1 psi per degree should be used. Most processes evidence this type of linearity at least within limits. It is generally convenient to speak of a "unit response curve" as the one produced by the unit valve movement. Dividing the ordinates of the dotted curve of *Fig.* 3 by the 2 psi valve change makes it coincide with the solid line produced by a unit (1 psi) valve change. In the same manner, a 0.1 psi change in valve position could have been made, and the result multiplied by ten to produce the same unit response curve. This would be a much better method if the process were nonlinear.

Required controller sensitivity shown by the process response curve of *Fig.* 3 is 0.1 psi per degree. With a setting thus determined the recovery curve of the controlled process would have adequate stability with an amplitude ratio of approximately 0.25. Increasing the controller sensitivity to 0.2 would cause instability while reducing it to 0.05 psi per degree would give excessive stability.

It is possible that the process of *Fig.* 2 could be linear, and if a linear valve were used, equal stability would be achieved under all operating conditions. In order to check for linearity, only a unit response curve at various load conditions need be plotted. If, as noted on *Fig.* 4, the only load change on the system was caused by varying inlet water temperature, the unit response curve at low load (warm inlet) and high load (cold inlet) would be identical provided that the pressure drop over the steam valve remained essentially constant. This would be entirely true if the condensing pressure in the coils were less than half the steam supply pressure at the high-load condition. Under these conditions, since the unit response curves are identical, the linear valve is ideal for the process and would give equal stability at all loads between minimum and maximum.

Instead of variations of inlet water temperature, the major load change on the process might be changes in water flow as shown in *Fig.* 5. The volume of water and consequently the heat capacity of the tank remain constant so a given increase in steam flow should start to raise the temperature at the same rate regardless of water flow. Again, the process is linear so that a linear valve should be used.

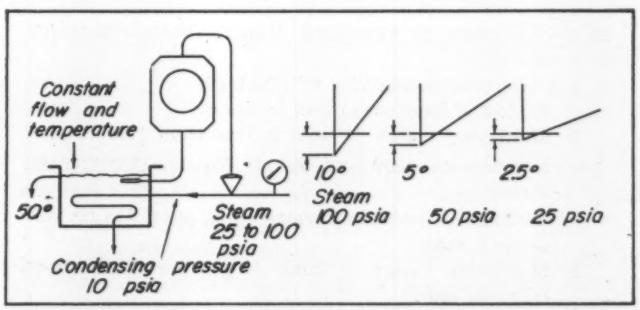
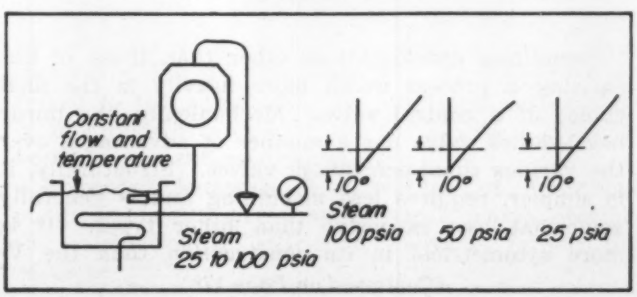


Fig. 6—Above—Unit response curves of this process vary with changes in steam pressure. Valve is linear

Fig. 7—Below—Use of equal-percentage valve in circuit of Fig. 6 results in identical unit response curves for all steam pressures

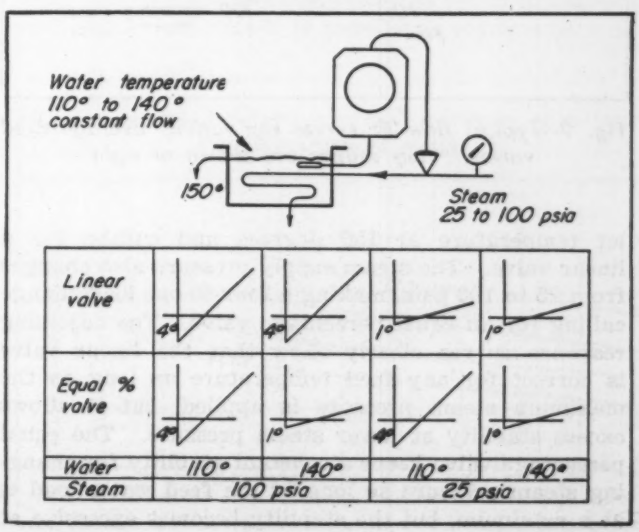


Load Changes Alter Curves

Suppose that the water flow is essentially constant and the inlet temperature as well, but the major change in load is variation in the steam supply pressure between 25 and 100 psi. This is a load change since it requires a change in valve position if the water temperature is to be maintained constant. Referring to *Fig.* 6 it can be seen that the two unit response curves at maximum and minimum loads are no longer identical. At lower steam pressure, the reaction rate is lower, giving a smaller *RL* intercept and indicating that a higher controller sensitivity can be used at this load.

It is easy to see why the unit response curves are different at each load condition. If a unit increase in valve opening causes a ten-degree-per-minute rise in

Fig. 8—Effects of linear and equal-percentage valves in process in which both the inlet-water temperature and the steam pressure vary



tank temperature with the steam supply at 100 psia, the same increase in valve area with 50 psia steam should only change the steam flow half as much and result in only five degrees per minute rise of tank temperature.

So the process, which was beautifully linear before, has become nonlinear, and the evidence indicates that the reason is somehow connected with the type of load change. As soon as different valve openings are required to pass the same quantity of steam an ugly nonlinearity develops.

How Process Can Be Linearized

The process of *Fig.* 6 can be made linear with respect to load by substituting an "equal percentage" valve for the linear one, as shown on *Fig.* 7. If a unit lift gives a ten-degree-per-minute change in tank temperature when the steam pressure is 100 psia, it should produce the same rate of rise when the steam pressure is 25 psia because the open area of the valve is four times as great and the disk is so shaped that the same unit lift makes four times the change in area. The valve derives its name from this "equal percentage characteristic"; a given lift at any opening increases the area a fixed proportion of the existing area.

It should be interesting to attempt to linearize a process having two sources of load change, one calling for a linear valve and one for an equal percentage valve. The process shown in *Fig.* 8 is subjected to a feed-water temperature change from 110 to 140 degrees, making a four-to-one load change with the outlet temperature at 150 degrees and calling for a linear valve. The steam supply pressure also changes from 25 to 100 psia, making a four-to-one load change calling for an equal percentage valve. The adjoining response curves clearly show that the linear valve is correct for any feed temperature as long as the maximum steam pressure is applied, but it allows excess stability at lower steam pressure. The equal percentage valve keeps a constant stability for changing steam pressure as long as the feed water load is at a maximum, but the stability becomes excessive at higher feed temperatures. Each valve is equally bad when it attempts to correct for the wrong process nonlinearity.

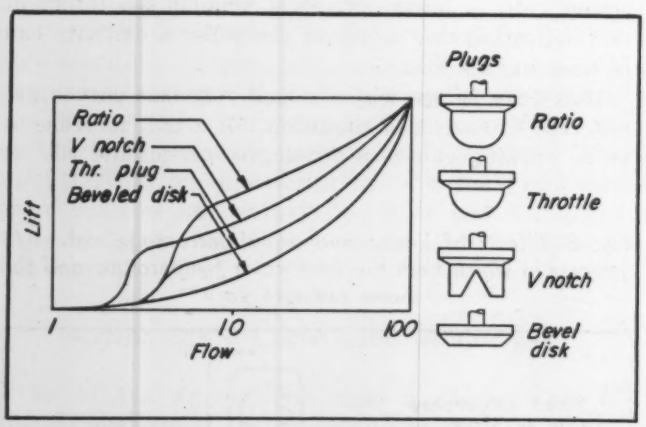


Fig. 9—Typical flow-lift curves for various average-sized valves. Plug shapes are shown at right

It might appear that a valve characteristic could be devised which would linearize the system completely, but this is not the case. When more than one type of load change occurs in the same process, there is no ideal solution and the choice of valve characteristics must be a compromise. In the foregoing example, where both load changes are of equal magnitude, either valve could be used and the only reason for choosing one type over the other would be on a basis of mechanical or structural characteristics, or possibly on availability.

Often in situations such as this, when two types of load changes are encountered in the same process, the load changes are of widely different orders of magnitude and the valve is selected that has the characteristics which will linearize the major load change. For example, if all the load changes so far considered came into the process, that is, feed water flow from 5 to 50 gpm, at a temperature between 50 degrees and 140 degrees, and steam pressure variation between 25 and 100 psia, the choice would be easy. A linear valve should be used because the water flow and temperature changes together amount to a load change of 100 to 1 and call for a linear valve, while the steam pressure range is only four to one in favor of the equal percentage valve. It would be a mistake to leave this example without pointing out that the addition of a steam pressure reducing valve, set for 25 psia, placed ahead of the linear control valve would eliminate the source of the nonlinear load change on the process and perfect linearity would result as in *Figs.* 4 and 5.

A simple guide for quickly determining the most desirable control valve for a given application follows:

DON'T BOTHER TO CONSIDER VALVE CHARACTERISTICS IF:

1. Controller sensitivity will be high
2. Period of oscillation will be short
3. Maximum range of load is less than two to one.

DON'T CONSIDER THE USE OF AN EQUAL PERCENTAGE VALVE IF:

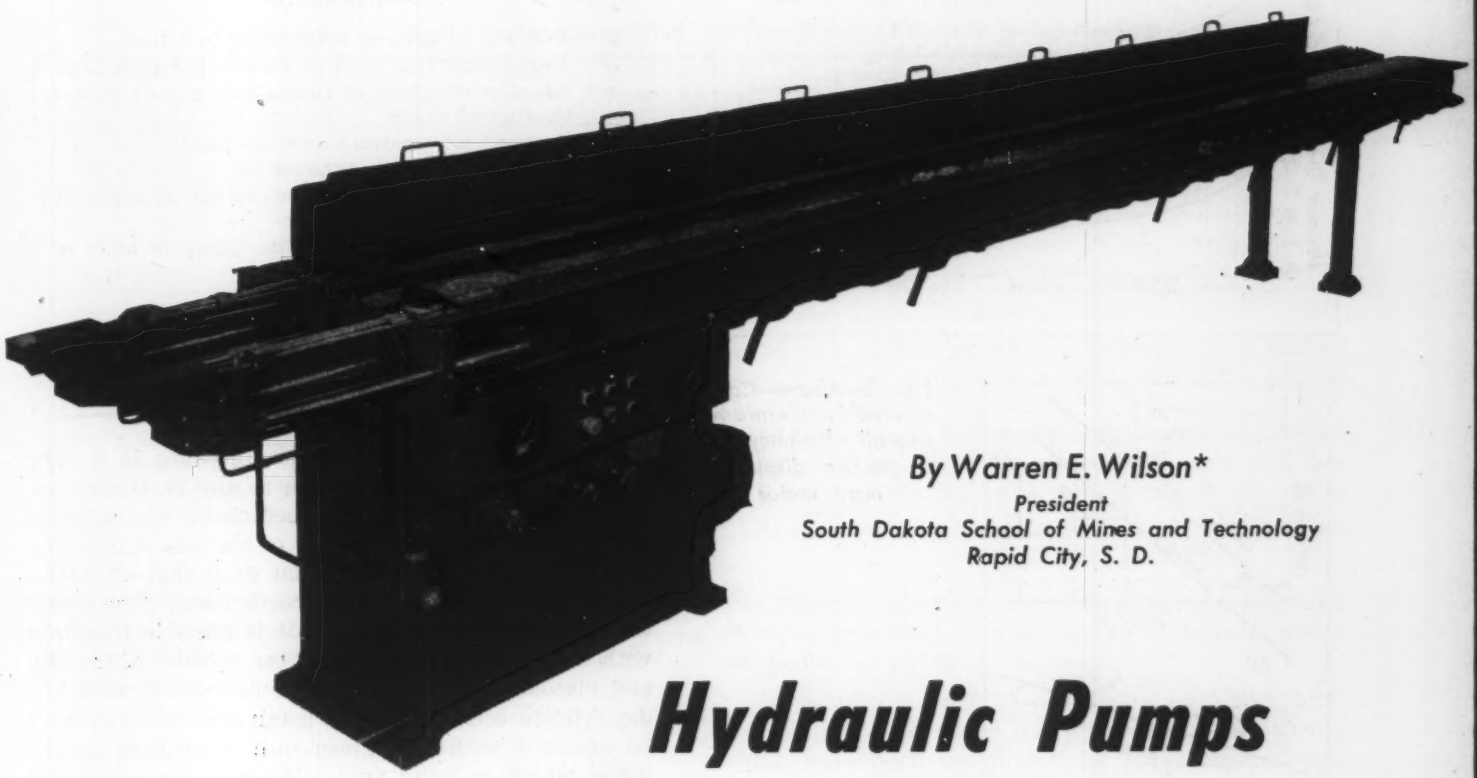
1. Controlled medium carries solid particles or will deposit scale
2. Maximum range of loads is greater than about eight to one
3. Major load change calls for a linear valve
4. Valve lag accounts for most of the effective process lag.

CONSIDER THE USE OF AN EQUAL PERCENTAGE VALVE IF:

1. Major load change calls for an equal percentage valve and none of the above conditions apply.

Sometimes considerations other than those of linearizing a process weigh more heavily in the final choice of a control valve. Mechanically, the linear beveled-disk valve has a number of advantages over the various equal-percentage valves. Structurally, it is simpler, requires less machining and is generally somewhat less expensive than other types. It is more symmetrical in its construction than the V-

(*Continued on Page* 178)



By Warren E. Wilson*
President
South Dakota School of Mines and Technology
Rapid City, S. D.

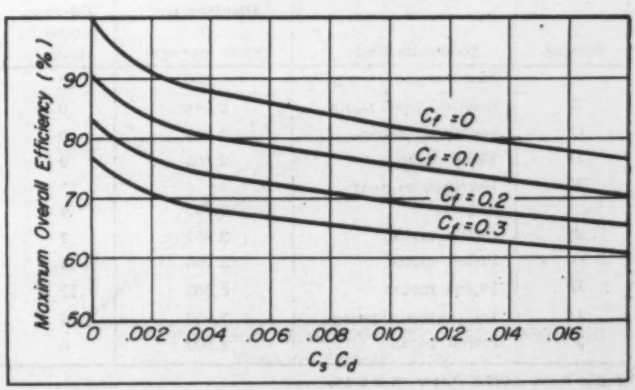
Hydraulic Pumps and Motors

... how to analyze and predict their performance under widely varying conditions of operation

TO BE able to predict the performance of a positive displacement pump or motor under all conditions of operation is highly desirable. In presenting performance data it is customary to use graphical means, showing efficiency, delivery and power as functions of speed, pressure and viscosity. However, the common methods of presentation are of such a nature that it is difficult, if not impossible, to predict performance at speeds and pressures different from those shown and for operation with liquids other than the one specified on the chart. The most common plotting shows efficiency, delivery and power as ordinates with pressure as abscissa, for a given speed and liquid. The user is quite commonly referred to the home office for additional information if he proposes to operate the pump with a different liquid or at a different speed.

Presented herewith is a method of describing pump and motor performance which makes possible the calculation of efficiency, delivery, torque and power under all conditions of operation. This method is based upon the fact that pump or motor performance can be described completely in terms of delivery and torque and that it is possible to express both de-

Fig. 1—Calculated maximum overall efficiency of a positive displacement pump



* A biographical sketch of the author appears on Page 162.

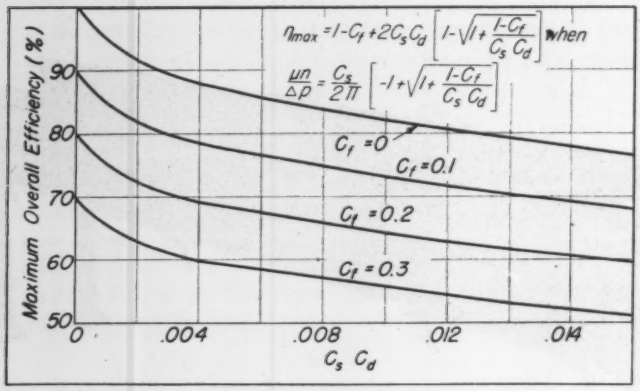


Fig. 2—Above—Calculated maximum overall efficiency of a positive displacement motor

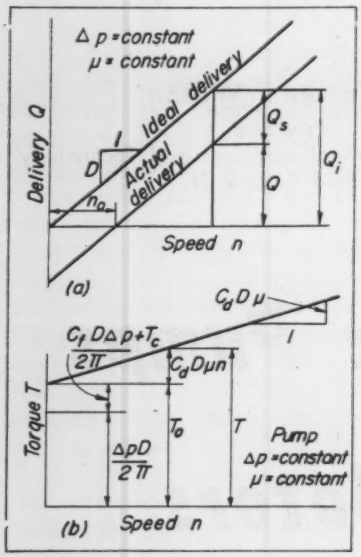


Fig. 3—Left—Method of plotting delivery and torque of a pump. Viscosity and pressure conditions are constant

livery and torque in terms of speed, pressure, liquid viscosity and pump or motor displacement.

Slip is described in terms of pressure, displacement, viscosity and a coefficient of slip. Torque due to viscous shear of the liquid is described in terms of displacement, viscosity, speed and a coefficient of viscous drag. Torque due to dry friction is described in terms of displacement, pressure and a coefficient of friction. These coefficients can be determined experimentally in a simple manner. They are dimensionless and are significant physical constants of the pump or motor, which are determined entirely by the geometry and physical characteristics of the unit.

Nomenclature

Q = Delivery in units of volume per unit time
D = Displacement in units of volume per revolution
n = Speed of rotation in revolutions per unit time
c_s = Coefficient of slip
Δp = Pressure differential across the pump
μ = Dynamic viscosity of the liquid
Q_r = Loss in delivery due to cavitation in the inlet region
T = Torque required to drive the pump in units of force times distance
c_d = Viscous drag coefficient
c_f = Dry friction coefficient
T_c = Frictional torque, which is independent of speed and pressure.

Because they describe the performance in a very basic manner without reference to any particular set of operating conditions, the coefficients are valuable in comparing the performance of various pumps and motors. The slip and frictional drag characteristics are described directly by the coefficients. The maximum overall efficiency which it is possible to attain with the unit is determined by the product of the slip and viscous drag coefficients in connection with the dry friction coefficient. This maximum efficiency may be attained with any given unit regardless of the liquid which is being used. However the speed and pressure at which the maximum is attained depends upon the viscosity of the liquid. The maximum occurs at a definite value of the number obtained by multiplying the speed by the viscosity and dividing by the pressure differential.

PERFORMANCE EQUATIONS: The performance of a pump can be described in terms of two simple equations, one of which expresses the delivery and the other the torque as a function of the pertinent variables. These equations are (see accompanying Nomenclature):

$$Q = Dn - \frac{c_s D \Delta p}{2\pi\mu} - Q_r \quad \ldots\ldots(1)$$

$$T = \frac{\Delta p D}{2} + c_d D \mu n + c_f \frac{D}{2\pi} \Delta p + T_c \quad \ldots\ldots(2)$$

Similar equations can be written for a fluid motor, differing only in the signs of the terms after the first on the right-hand side of the equations. In all cases

TABLE I—Pump and Motor Coefficients

Symbol	Hydraulic Unit	Displacement D (cu in. per rev)	Friction Torque T_c (lb-in.)	Coefficients: Viscous drag c_d	Slip c_s	Dry friction c_f	Product $c_s c_d$	Calc. eff. η_{max} (%)
A	Internal-gear pump	1.205	13	5.95×10^4	3.35×10^{-7}	0	0.0199	75.7
B	Internal-gear pump	2.965	0	9.77×10^4	1.02×10^{-7}	0.0446	0.0100	79.0
C	Spur-gear pump	2.965	0	10.25×10^4	0.48×10^{-7}	0.179	0.0050	74.3
D	Vane pump	2.865	0	7.30×10^4	0.477×10^{-7}	0.212	0.00348	74.1
E	Herringbone-gear pump	0.652	4	1.20×10^4	9.00×10^{-7}	0.200	0.0108	69.0
F	Piston motor	2.060	7	22.9×10^4	....	0.067	.....	...
G	Piston motor	1.000	12	9.3×10^4	....	0.094	.....	...
H	Piston motor	3.365	17	6.46×10^4	....	0.0875	.....	...
I	Internal-gear pump	1.800	13	5.06×10^4	1.6×10^{-7}	0.075	0.0081	78.3
J	Piston pump	3.600	0	16.8×10^4	0.15×10^{-7}	0.045	0.0020	87.0

Table from ASME Paper 48-SA-14.

TABLE II.

Comparison of Pump Performance with Varying Speed, Pressure and Viscosity

Case No.	Kinematic Viscosity (SSU)	Speed (rpm)	Pressure (psi)	Dynamic Viscosity (slug/ft sec)	$2\pi\mu n/\Delta p$	Pump B Eff.			Pump D Eff.		
						Vol. (%)	Tor. (%)	Over. (%)	Vol. (%)	Tor. (%)	Over. (%)
1	300	1200	200	0.0011	4.8×10^{-6}	98	66	65	99	64	63
2	1600	1200	200	0.0662	41.0×10^{-6}	99	21	20	99	24	24
3	300	1200	1000	0.0011	1.4×10^{-6}	92	85	78	97	76	74
4	300	600	1000	0.0011	0.7×10^{-6}	86	90	77	93	80	74
5	1600	600	1000	0.0062	4.0×10^{-6}	97	70	68	99	67	66
6	1600	600	200	0.0062	20.5×10^{-6}	99	33	33	99	37	37

the system of units used must be consistent.

The power output P_{out} and power input P_{in} can be expressed directly from the equations for torque and delivery making use of the basic relationships:

$$P_{out} = Q\Delta p$$

$$P_{in} = 2\pi Tn$$

Overall efficiency is defined as the ratio between power output and power input.

Volumetric efficiency of a pump is defined as the ratio between the actual delivery and the ideal delivery.

Volumetric efficiency of a motor is defined as the ratio between the ideal delivery and the actual delivery.

Torque efficiency of a pump is defined as the ratio between the ideal torque and the actual torque.

Torque efficiency of a motor is defined as the ratio between the actual torque and the ideal torque.

It can be shown that the product of the volumetric efficiency and the torque efficiency is equal to the overall efficiency.

By means of suitable mathematical manipulations it can be shown that, if the quantities Q_r and T_c are negligibly small, as they usually are found to be, the maximum overall efficiency which can be obtained with a pump has a definite value which occurs at a specific numerical value of the dimensionless parameter $2\pi\mu n/\Delta p$. In *Figs.* 1 and 2 the maximum efficiency is shown as a function of the product $c_s c_d$ and the coefficient c_f, for a pump and a motor.

DETERMINATION OF COEFFICIENTS: The numerical value of the coefficients of a pump can be determined experimentally. This procedure has been discussed in greater detail elsewhere* and is reviewed here for ready reference.

Torque and delivery of the pump should be measured under conditions of constant liquid temperature at the pump intake, with various pressures and speeds. The data are best plotted as shown in *Fig.* 3. The slope of the torque lines is $c_d D\mu$ as indicated. The slope of the delivery lines is the displacement D. Knowing μ, the value of c_d can be calculated.

Torque at zero speed is found by extending straight lines through the plotted points for torque versus speed at constant pressure, until they intersect the torque axis. This value of the torque is independent of both speed and pressure, and equal to the sum of the ideal torque $\Delta pD/2\pi$, the dry friction torque $c_f \Delta pD/2\pi$, and the constant friction torque T_c.

* ASME paper No. 48-SA-14.

Delivery at zero speed is determined in a similar manner. This delivery is negative and is the slip at the given pressure.

If the torque at zero speed and the slip are plotted as indicated in *Fig.* 4, the values of T_c, c_f and c_s can be found as indicated. The slope of the torque line is

$$\frac{D(1+c_f)}{2\pi}$$

The intercept on the vertical axis is T_c, and the slope of the slip-pressure line is $c_s D/2\pi\mu$. Since D and μ are known, c_f and c_s can be calculated.

EXPERIMENTAL RESULTS: In TABLE I are shown experimentally determined pump and motor coefficients which have been established by the procedure out-

Fig. 4—Right—Method of plotting torque and slip at zero speed, which permits calculation of friction and slip coefficients

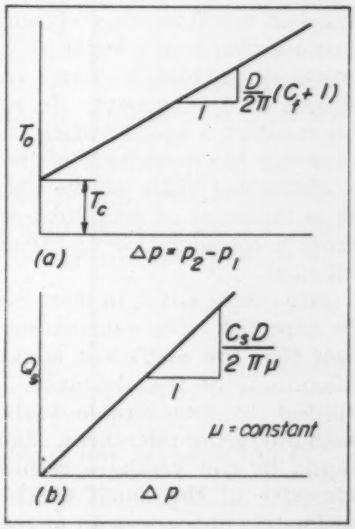
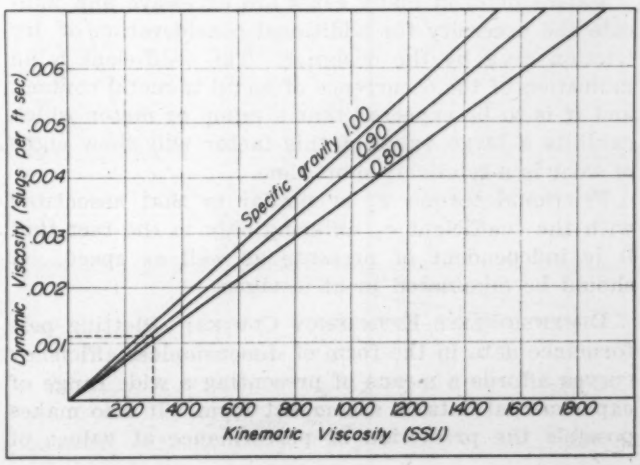


Fig. 5—Below — Viscosity conversion chart for oils



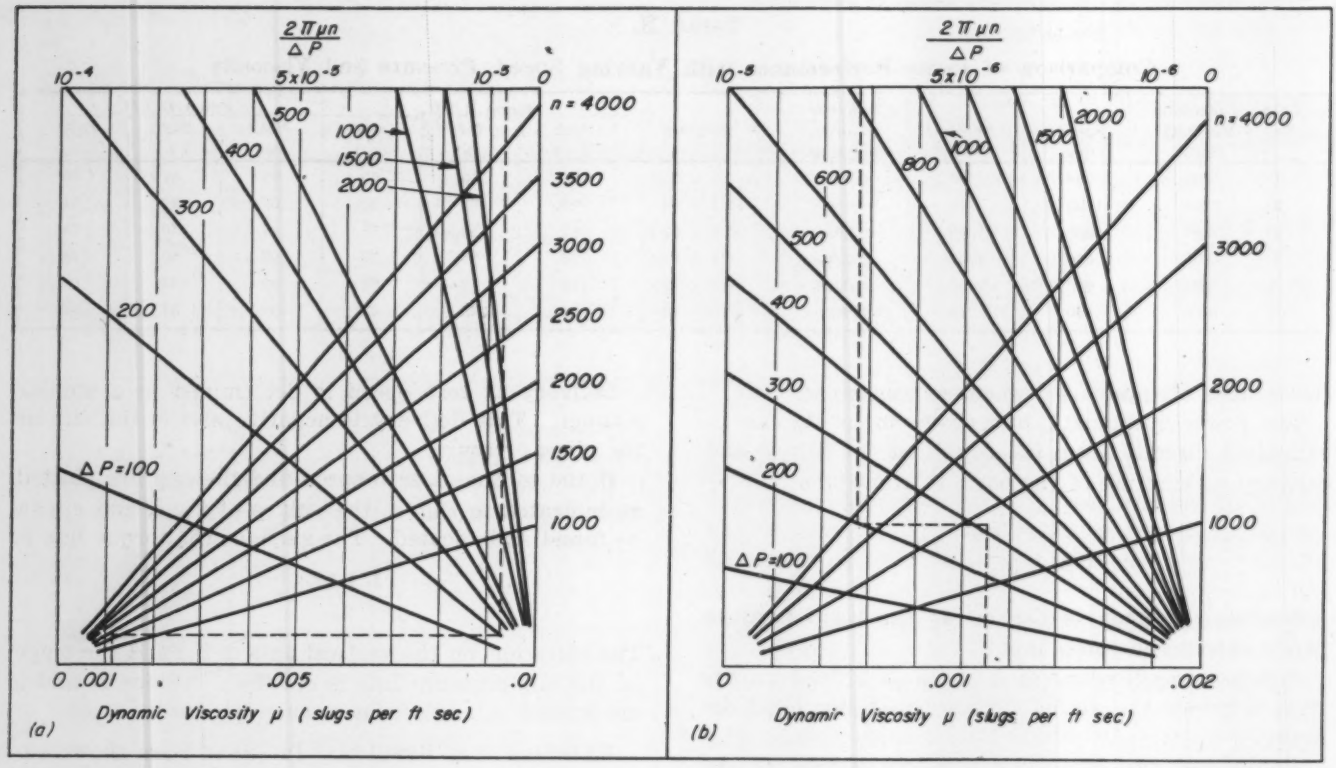


Fig. 6—Chart for determining performance parameter

lined in the foregoing. Products of several different manufacturers are included in the list. Some units were stock models while others were in various stages of development. In no case were the pumps operated at a speed sufficiently high to indicate conclusively the magnitude of the cavitation loss Q_r.

Numerical value of the viscous drag coefficient c_d is of the order of magnitude which would be expected from a consideration of calculated values of this coefficient.

Slip coefficient c_s in most cases is larger than would be expected. The explanation undoubtedly lies in the fact that the coefficient is extremely sensitive to the magnitude of the clearance. Clearances in turn are subject to considerable variation due to necessary manufacturing tolerances. In addition, heating of the liquid in slip passages results in a decrease in the viscosity of the liquid which increases the slip and ultimately appears as an increase in c_s.

Values of c_f in many cases are excessive and indicate the necessity for additional consideration of dry friction drag by the designer. The coefficient is an indication of the occurrence of metal-to-metal contact, and it is to be expected that a pump or motor which exhibits a large value of this factor will show signs of wear in a relatively short time.

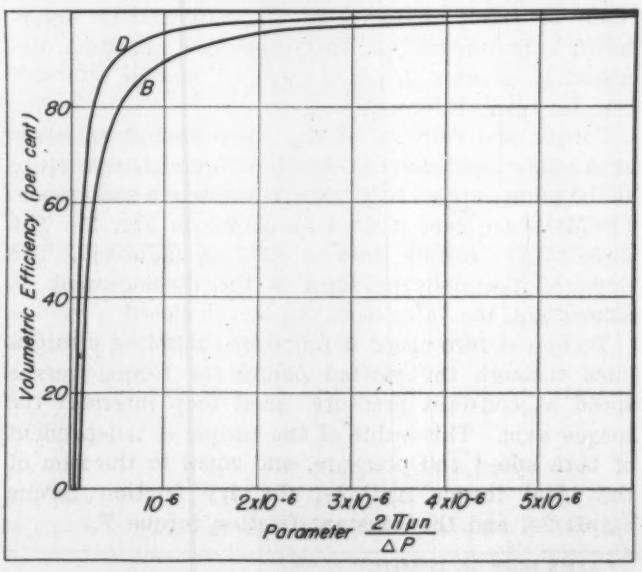
Frictional torque T_c is similar to that associated with the coefficient c_f, differing only in the fact that it is independent of pressure as well as speed. It should be eliminated in all designs.

DIMENSIONLESS EFFICIENCY CURVES: Plotting performance data in the form of dimensionless efficiency curves affords a means of presenting a wide range of experimental data in a compact form. It also makes possible the prediction of performance at values of viscosity, speed and pressure which are not readily obtained with a particular experimental setup. Since performance is a function of the parameter $\mu n/\Delta p$ and not μ, n and Δp individually, an infinite number of combinations of these variables is represented by a single experimental determination giving an efficiency at a specified value of $\mu n/\Delta p$.

Using the experimentally determined values of the performance coefficients in the equations for the various efficiencies it is possible to plot curves representing efficiency as a function of $\mu n/\Delta p$.

APPLICATIONS: To illustrate and clarify the application of the foregoing concepts, three examples are worked out and discussed, making use of graphical means for the calculation of the significant quantities.

Fig. 7—Volumetric efficiencies of two pumps compared



In the first example the value of the parameter $2\pi\mu n/\Delta p$ is determined for various selected operating conditions.

In the second the performance of two selected pumps is determined from the efficiency curves using the operating conditions of the first example to establish the comparison points.

In the third example the conditions for maximum efficiency are determined for one of the two selected pumps.

EXAMPLE 1: To compare the performance of two pumps over a reasonably wide range of operating conditions, those identified in TABLE I as *B* and *D*, and the following values of viscosity, speed and pressure were selected:

Viscosity	300 SSU and 1600 SSU
Speed	600 rpm and 1200 rpm
Pressure	200 psi and 1000 psi

Specific gravity of the liquid is taken to be 0.85.

To simplify the calculation of the parameter $2\pi\mu n/\Delta p$ the chart shown in *Fig.* 5 was prepared. This chart makes possible the conversion from kinematic viscosity to dynamic viscosity when the specific gravity and the kinematic viscosity are known. The dashed line indicates the procedure to be followed in using the chart. With a kinematic viscosity of 300 SSU and a specific gravity of 0.85 the chart is entered at the value 300 SSU on the abscissa and followed vertically to the line indicating a specific gravity of 0.85 (or interpolated between the 0.80 and 0.90 specific gravity lines as is necessary in this chart). Proceeding horizontally from this point to the intersection with the vertical scale, the value of the dynamic viscosity is read as 0.0011 slugs per foot second for this example.

With the dynamic viscosity known, values of speed and pressure may be selected and the parameter $2\pi\mu n/\Delta p$ calculated. This calculation is greatly simplified by the use of the chart shown in *Fig.* 6, as follows.

Selecting values for speed and pressure $n = 1800$ rpm and $\Delta p = 200$ psi, the chart is entered at viscosity μ equal to 0.0011 (previously found) and followed vertically to a point between $n = 1000$ and $n = 2000$ corresponding to $n = 1800$. Proceeding horizontally from this point to the intersection with the line indicating a pressure of 200 psi, and then vertically to the horizontal scale at the top of the chart, the value of the parameter $2\pi\mu n/\Delta p$ is read as 7.2×10^{-6} for this example. Either chart can be used, but here *Fig.* 6*b* obviously gives a more accurate result.

If it is desired to evaluate $2\pi\mu n/\Delta p$ by calculation, speed n must be expressed in revolutions per second and pressure Δp in pounds per square foot, so that units will be consistent and the parameter strictly nondimensional. The conversion constants are included in *Fig.* 6.

The foregoing procedure can be used to calculate the value of the parameter $2\pi\mu n/\Delta p$ for a wide range of operating conditions. In TABLE II six different operating conditions are indicated by appropriate values of viscosity, speed and pressure. Corresponding values of the parameter $2\pi\mu n/\Delta p$ are shown.

EXAMPLE 2: To compare the performance of the two selected pumps, *B* and *D* of TABLE I, the volumetric efficiency, torque efficiency and overall efficiency of each have been calculated from the performance coefficients and plotted against $2\pi\mu n/\Delta p$ in *Figs.* 7, 8 and 9.

From these curves the appropriate values of the efficiencies have been determined and are tabulated in TABLE II. Consideration of these tabulated values, the curves and the performance coefficients reveal interesting points of comparison between these pumps.

Most significant differences between the two are characterized by the slip and dry friction coefficients. Pump *B* has a significantly larger slip coefficient indicating that its performance with respect to volumetric efficiency is inferior to that of pump *D*. This is illustrated graphically in *Fig.* 7 wherein it is apparent that the volumetric efficiency of pump *D* exceeds that of pump *B* at all values of the parameter $2\pi\mu n/\Delta p$.

Dry friction coefficient of pump *B* is significantly

Fig. 8—Comparison of torque efficiencies of two pumps

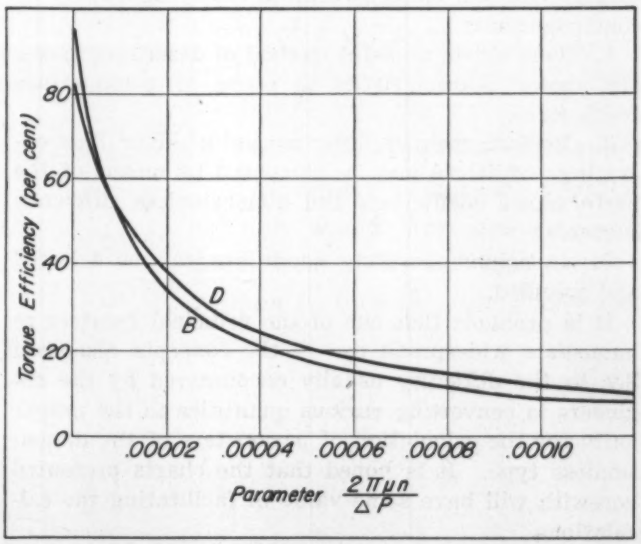
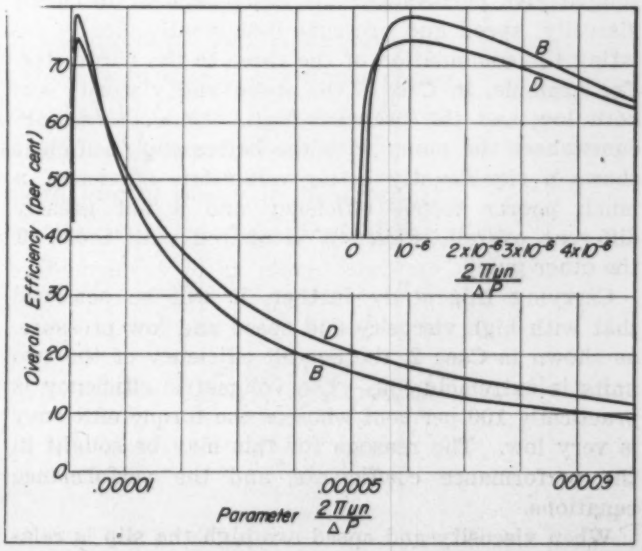


Fig. 9—Overall efficiencies of two pumps compared



lower than that of pump *D*, but as will be noted in *Fig.* 8 the torque efficiencies of the two pumps are not as simply related as are the volumetric efficiencies. This is due to the fact that the viscous drag coefficient of pump *B* is somewhat larger than that of pump *D*. At high values of the parameter $2\pi\mu n/\Delta p$, that is at high speeds or viscosity or with low pressure, the viscous friction is relatively more important than is the dry friction.

Overall efficiency being the product of volumetric and torque efficiencies must necessarily exhibit characteristics of each. It is found therefore that the overall efficiency of pump *D* exceeds that of pump *B* at low values of the parameter $2\pi\mu n/\Delta p$, when volumetric efficiency is changing rapidly; then the overall efficiency of pump *B* exceeds that of pump *D* when dry friction is most significant; and finally at very high values of the parameter the performance of pump *D* shows a higher overall efficiency.

It may be desirable for the reader who is not fully conversant with the concept of the dimensionless parameter $2\pi\mu n/\Delta p$ to consult TABLE II and study the

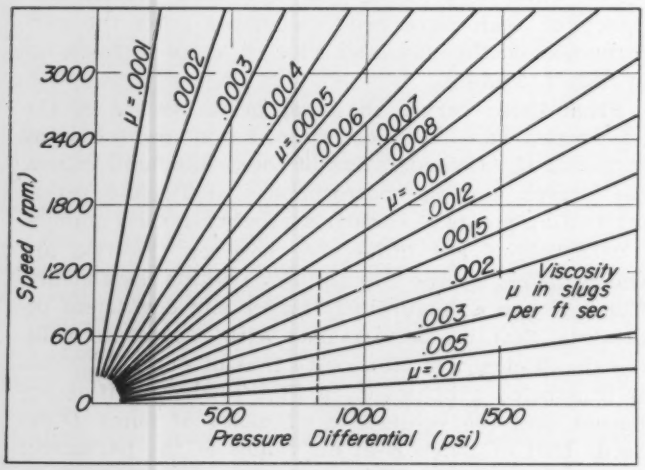


Fig. 10—Conditions for maximum overall efficiency of pump B shown on the curve in Fig. 9

comparative performance of the pumps in terms of viscosity, speed and pressure individually, finally relating the combination of the three to the parameter. For example, in Case 6 the speed and viscosity are both low and the pressure high. Under these circumstances the pump with the better slip coefficient shows a significantly better volumetric efficiency, a much poorer torque efficiency and a not greatly different overall efficiency, compared with those of the other pump.

Carrying this study further, it will be observed that with high viscosity and speed and low pressure, as shown in Case 2, the overall efficiency of the two units is extremely low. The volumetric efficiency is practically 100 per cent whereas the torque efficiency is very low. The reasons for this may be sought in the performance coefficients, and the performance equations.

When viscosity and speed are high the slip is relatively small compared to the total delivery, resulting in a high volumetric efficiency which is close to 100 per cent for both units even though the slip of the one is about twice that of the other. On the other hand the torque efficiency is low because the viscous drag, which is proportional to the product of speed and viscosity, is large. Since the viscous drag coefficients of the two pumps are not greatly different the torque loss at high values of viscosity and speed are of the same order of magnitude, resulting in comparable torque efficiencies.

Determining Optimum Overall Efficiency

EXAMPLE 3: To facilitate determination of the conditions for optimum overall efficiency, *Fig.* 10 has been prepared. It has been pointed out previously that maximum efficiency occurs at a particular value of the parameter $2\pi\mu n/\Delta p$. Obviously there is an infinite number of values of the viscosity, speed and pressure which in combination yield the same numerical value of the parameter. Making use of *Fig.* 10 and knowing any two of the three quantities viscosity, speed and pressure it is possible to determine the third which, in combination with the other two, gives the conditions for maximum efficiency.

Use of the chart may be illustrated by considering the viscosity and speed to be those of Case 1 in TABLE II and then determining the pressure which corresponds to these two for optimum operating conditions. To accomplish this the chart is entered at the point on the speed scale corresponding to 1200 rpm and followed horizontally to the intersection with a viscosity line interpolated between 0.001 and 0.0012 for the value 0.0011 indicated in TABLE II. From this intersection a vertical projection down to the intersection with the horizontal scale indicates a pressure of 830 psi. It is apparent that this pressure is considerably higher than the 200 psi of Case 1. The value of $2\pi\mu n/\Delta p$ for Case 1, TABLE II, is 4.8×10^{-6}. If the pressure were increased to 830 psi the value of the parameter would be approximately 1.1×10^{-6} which is close to the peak shown in *Fig.* 9.

CONCLUSION: On the basis of the theory outlined briefly in this article and the consideration of experimental data and material derived therefrom it may be concluded that:

1. There exists a useful method of describing pump and motor characteristics in terms of performance coefficients.
2. Performance of different units under like operating conditions may be compared by means of the performance coefficients and dimensionless efficiency curves.
3. Optimum operating conditions can be selected and specified.

It is probable that one of the principal barriers to immediate widespread use of the concepts discussed lies in the difficulty usually encountered by the engineers in converting various quantities to the proper units for the calculation of parameters of the dimensionless type. It is hoped that the charts presented herewith will have some value in facilitating the calculations.

MACHINE *Editorial* DESIGN

Achievement Deserves Recognition

Is credit being given where credit is due in connection with current accomplishments in the design field? This question is brought closely to mind by the belated celebration of the Wright brothers' first flight, which was held at the Smithsonian Institution on December 17. On that date the original Wright airplane was accepted by the institution as the first successful heavier-than-air flying machine to be developed—exactly forty-five years after the first flight was made!

While the Wright brothers' invention holds top rank among those that have marked the course of world history, and consequently is in a class of its own, continuous developments are taking place in the design of all types of machines that similarly are not recognized fully when they are made. Through the efforts of single engineers or groups of designers in engineering departments of machine-building companies new machines are being created constantly which have a distinct bearing on the companies' advancement and prosperity, as well as on the national well-being. It is only in rare instances, however, that the engineer or engineers involved receive the full recognition that rightly is theirs.

Without recurring accomplishments in design, skillful management of a machine-building company cannot in itself assure the success of the organization; nor can superlative salesmanship long carry the ball. It is only through the competent efforts of the men engaged in design and development that an otherwise progressive company can continue to forge ahead or hold its own in a competitive field.

Under such circumstances would it not be fitting for top management to recognize more fully that—as stated by E. G. Bailey in his presidential address at the recent annual meeting of the ASME—"the product is the life blood of a company"? If this fact were accepted at true value and inventors, designers or groups of engineers were rewarded in a manner commensurate with the success of each accomplishment, even greater efforts to create really outstanding designs unquestionably would result.

Machinery companies adopting a more liberal policy in this respect not only would show due appreciation of the work of their engineering department staffs but also would place themselves in a much stronger position to face the future with confidence.

L. E. Jerry

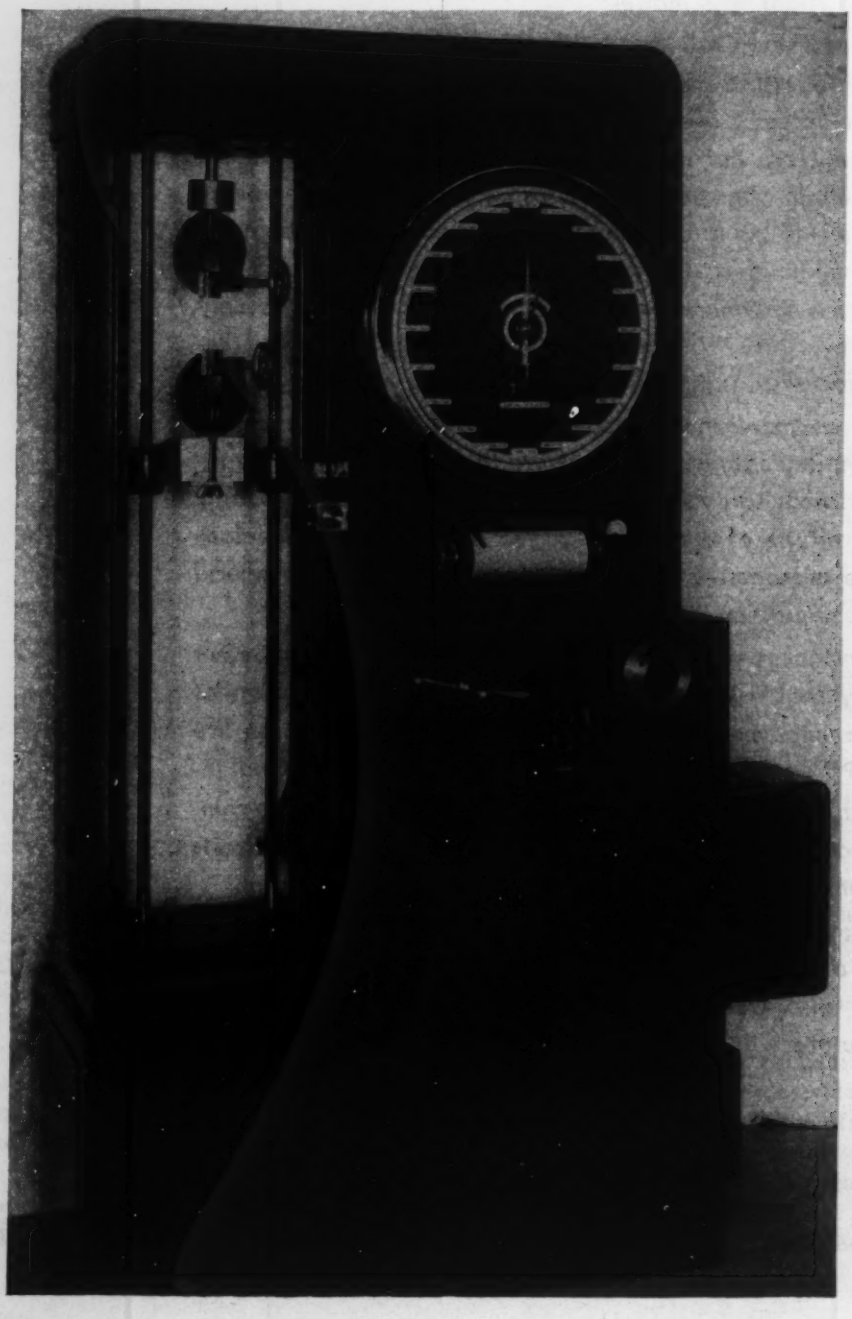
DESIGNS OF THE

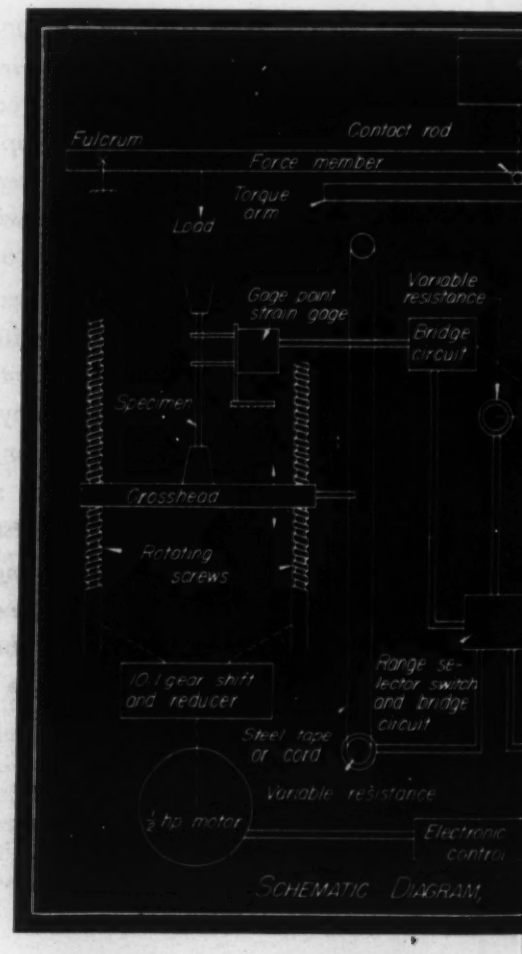
All-Electronic Testing Machine

DESIGNED primarily for low-capacity research work, the "Electromatic" tester shown below utilizes electronic control of the loading, force measuring and strain measuring systems. Capable of applying loads up to 5000 pounds, the machine is nevertheless sensitive within one-tenth of one per cent. A schematic diagram of the operation of the machine is shown below, right.

The test load or force is "weighed" by applying the load to a force member pivoted at one end. A movable contact rod transfers the load to a torque arm, which is rigidly attached to a standard torsion rod of a special alloy. A motion detector measures the exceedingly small deflection of the torsion rod, the resulting signal is amplified, and the load recording motor restores the detector to a null condition, at the same time indicating the load on the dial and recording drum.

For material having a high per cent elongation, the motion of the crosshead provides an accurate indication of the strain, providing that

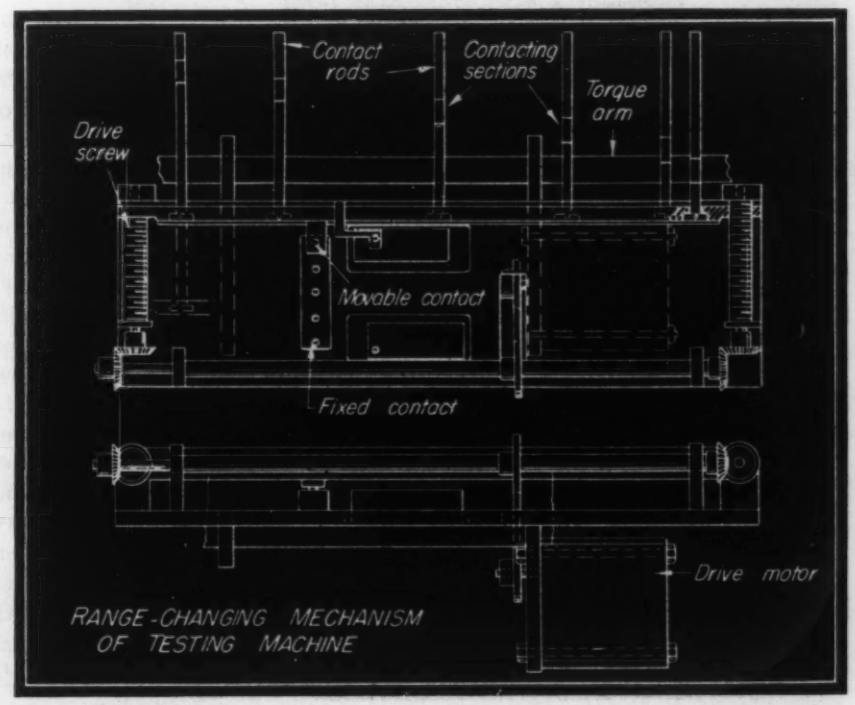




E MONTH

the movement of the weighing system is small. Movement of the weighing head in this machine is in all cases less than 0.002-inch. For material having a very small per cent elongation, the strain is determined by attaching a gage-point strain instrument (essentially a movable core transformer) to the specimen. Output of the strain indicator is amplified and causes the recording drum to rotate. Horizontal movement of the load indicating pen together with rotation of the recording drum produces accurate stress-strain curves automatically. Strain rates are variable from 0.05 to 20 inches per minute.

The method of adjusting the range of the machine is shown in the drawing above. The range change device is attached to the torque arm. A set of contact rods—one for each range of the machine—is positioned laterally between the force member and torque arm by a motor-driven shifting mechanism. These rods have raised contacting sections spaced at different positions along their lengths, so that for a given lateral position of the rod assembly, only one contacting section will engage the force member and torque arm. The position of any given contacting section along the length of the torque arm determines the effective lengths of the force member and torque arm. The ratio of the lengths establishes the per cent of the applied load transmitted to the torsion rod, thus selecting the range of the machine. With the contacting section of the extreme right-hand rod in contact, as shown, the system is in the condition of maximum stiffness.



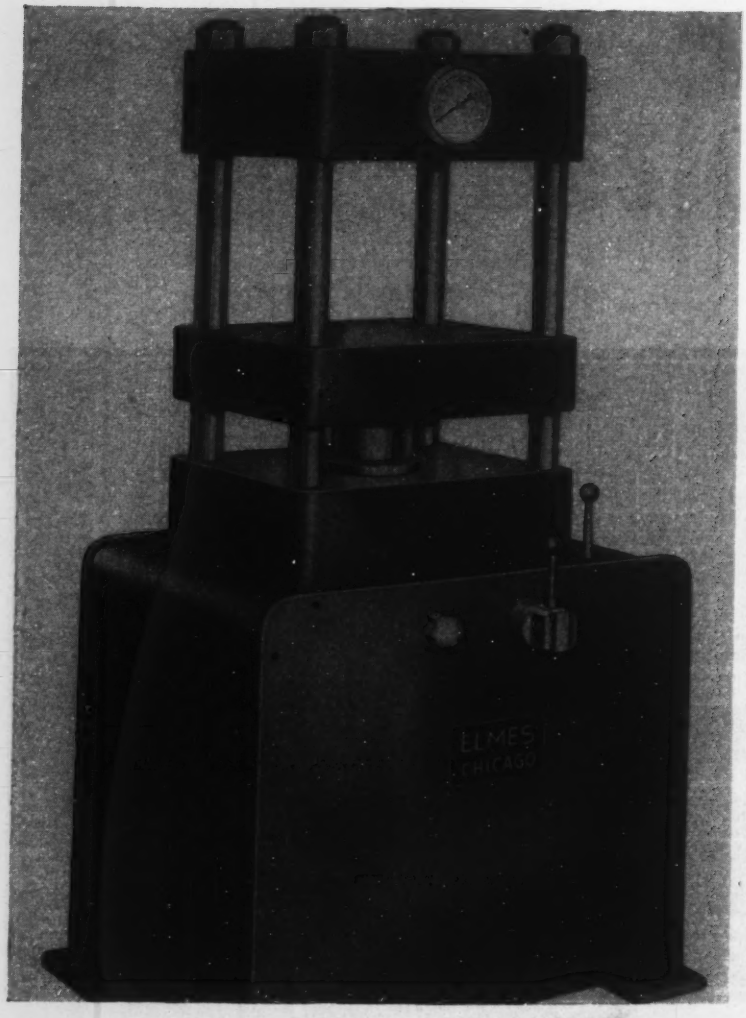
RANGE-CHANGING MECHANISM OF TESTING MACHINE

A series of fixed contact points —one for each contact rod—is fastened to the frame of the range changing device. A movable contact is attached to, and moves with, the rod assembly. When one of the raised contacting sections is in the proper lateral position between force member and torque arm, the movable contact point engages the corresponding fixed contact point, and an indicator light on the board shows the range in which the machine is operating. Manufacturer. Tinius Olsen Testing Machine Co., Willow Grove, Pa.

STROMATIC TESTING MACHINE

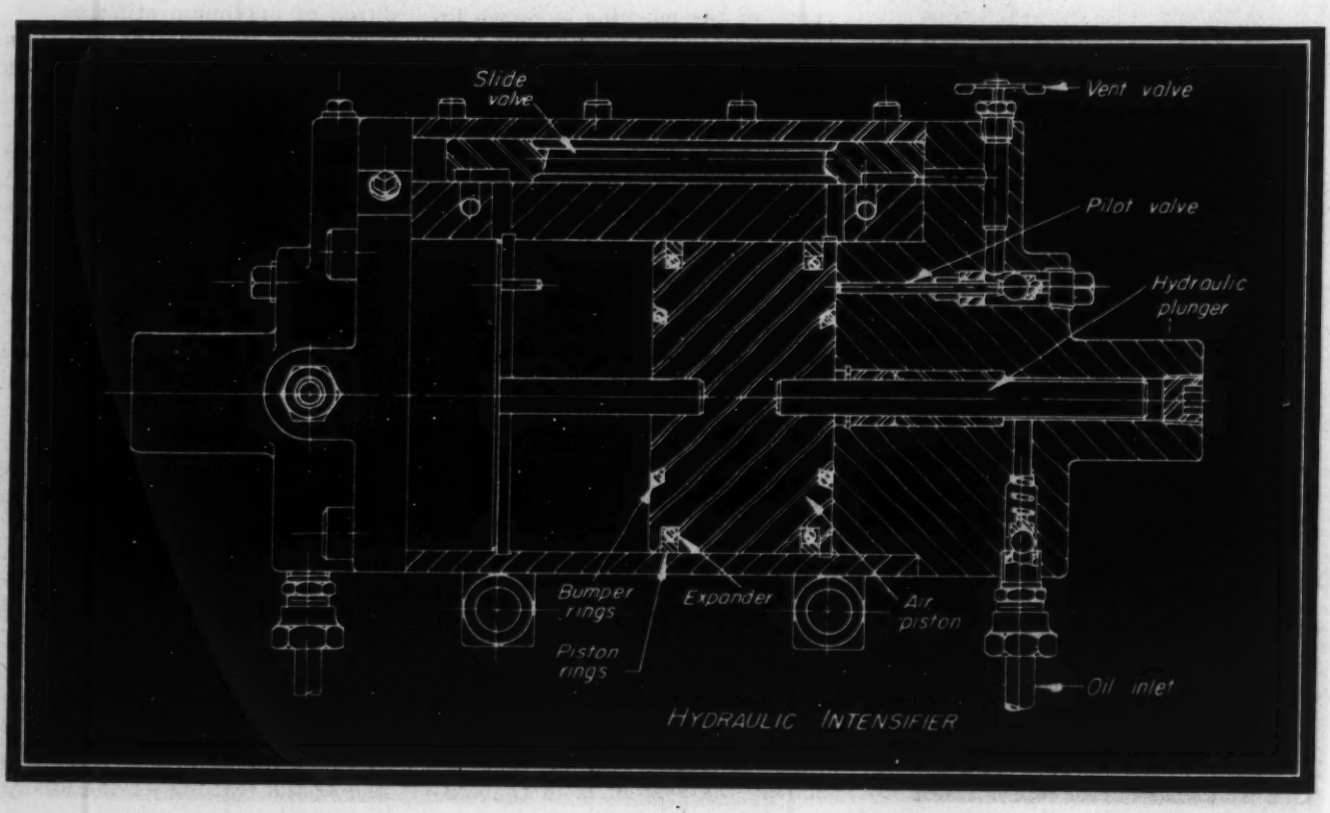
Air-Operated Press

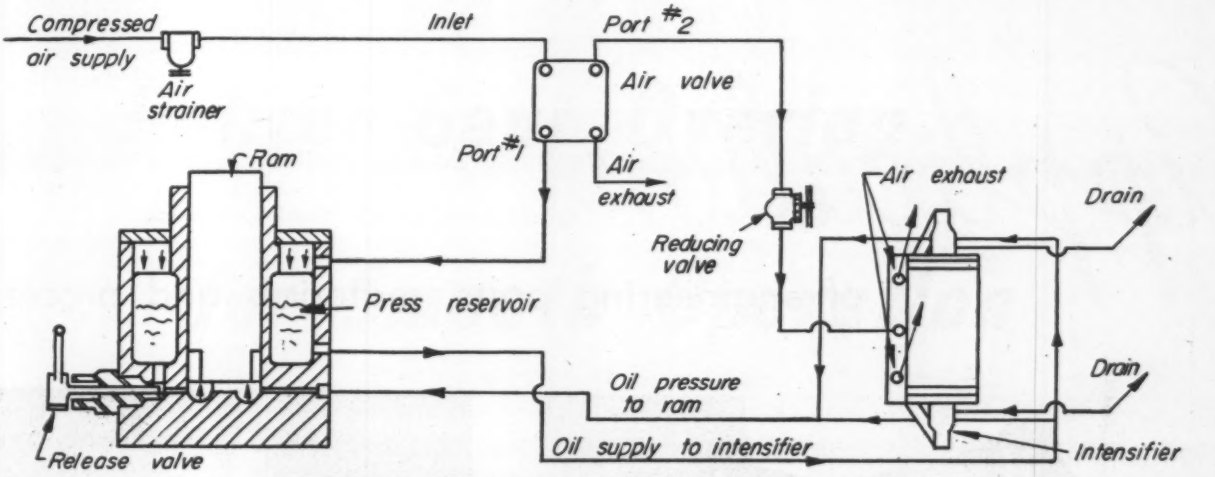
HOLDING a preset pressure on a yielding load such as encountered in plastic molding is one of the features of the air-hy-



draulic press shown in the photograph on the left. Designed for small production work, the pumpless, motorless machines use compressed air as the source of power to a "hydraulic intensifier". This intensifier is identical in action to a simplex, double-acting steam pump; employing a reciprocating air-driven piston which operates two hydraulic pump heads or plungers on opposite ends of the cylinder. The general construction of the intensifier may be seen from the cross section drawing below. Reciprocating action of the air piston is controlled by an air operated shuttle or slide valve having a flat seating surface. Small pilot valves in either end of the cylinder are tripped by the air piston at the end of its stroke and admit air to the proper end of the slide valve. Two step-joint type piston rings are installed in the air piston, using O-rings for expanders. Rubber O-rings are also imbedded in both of the piston faces to act as bumpers at the end of the stroke.

Operation of the air-hydraulic system is as follows (refer to schematic diagram top of next page): When the three-way control valve is moved to "closing" position, air passes through port No. 1 of the valve and is introduced above the liquid level in the press reservoir. Hydraulic pressure then raises the platen at rapid-closing rate. Reversing the valve lever to the "press" position diverts the air through port No. 2 into the intensifier, actuating the air slide valve and piston, and providing a continuous hydraulic pressure



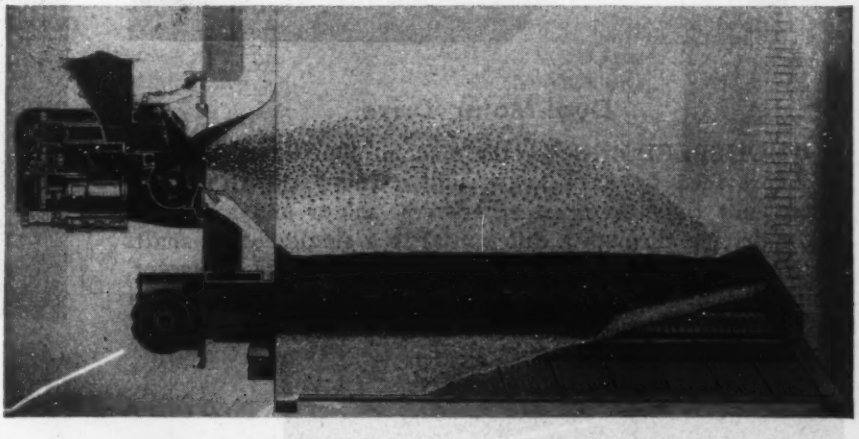


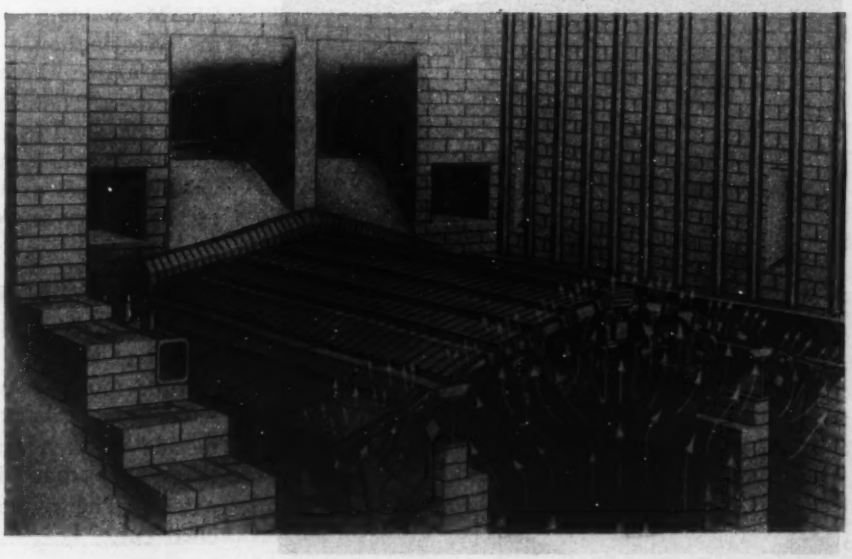
SCHEMATIC DIAGRAM OF AIR-HYDRAULIC PRESS

through the intensifier outlet (not shown) to the press ram. Minimum air pressure of 90 psi develops hydraulic pressure of 6000 psi, since the ratio of effective areas of the air piston and hydraulic plunger is about 75 to 1. Ram pressure is governed by a preset reducing valve in the air supply line. When the set pressure is reached the device stops, but will resume pumping if a drop in load resistance occurs and thus will regain and hold the desired preset pressure. Manufacturer: Elmes Engineering Works, Chicago.

Spreader Type Stoker

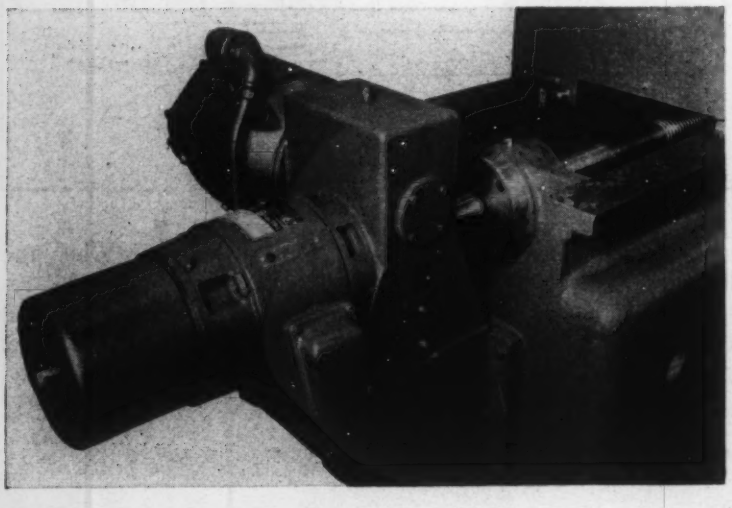
COMPLETE combustion of any grade of coal is possible with the stoker shown in cross section, center, right. Coal, fed to the air-cooled, hydraulic motor-driven rotor by two long-stroke, slow-speed rams, is trajected so that it falls evenly over the length of a linked grate. Undulation of the grate keeps the fuel bed active and moving toward the ash discharge grates at the sides, from which ashes are removed without interrupting the coal feed or losing steam pressure. Construction of the grate and path of flow of the primary air supply are shown at right, below. A deficiency of primary air rising through the grate is deliberately maintained so that the resulting monoxides can be burned in a secondary air supply above the trajectory of the incoming fuels. The stoker is powered by a constant-speed motor or turbine supplying hydraulic pressure for all controls and drives. Manufacturer: Westinghouse Electric Corp., Pittsburg.





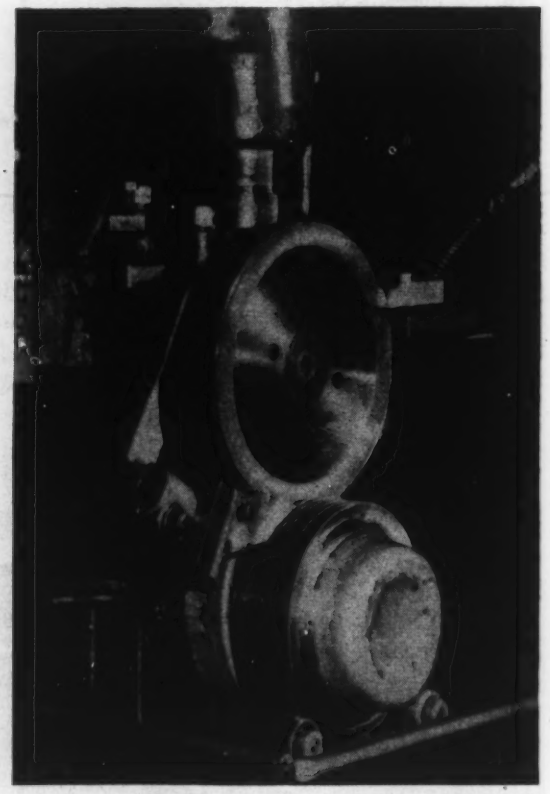
Applications

of engineering parts, materials and processes



Dual-Motor Drive

MULTISPEED drive for the machine tool shown above is provided by a packaged unit. This General Electric power unit consists of an ac traverse motor and a dc feed motor driving through a differential to a single output shaft. A traverse speed of 405 rpm is provided by the ac motor, while by the use of an electronic control for the dc motor a feed range of 6.3 to 63 rpm is achieved.



Welds Spiral Fin

SEAM welding joins the spiral fins to their shells in Westinghouse refrigerator compressor units. As shown above, the cooling fin is automatically welded to the shell in a Thomson welder. Held by the lower welding head the shell is rotated and advanced to give correct fin spacing. Simultaneously, a device mounted ahead of the welding wheel provides a slot through which the fin is fed at the proper angle.

Wheels Molded In Two Colors

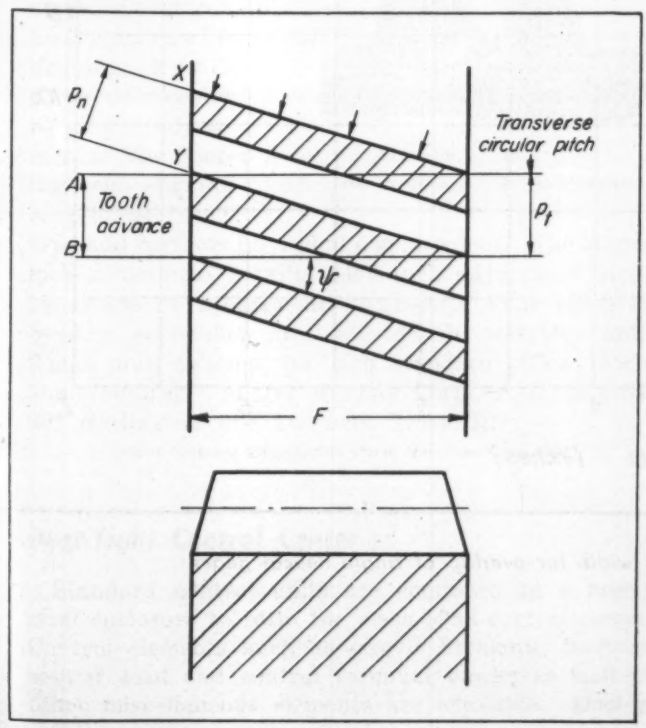
PLASTIC two-color numeral wheels on the counter shown at the left, are formed from Tenite by a double injection molding process. The white numerals are first molded on a backing ring. The ring containing the numerals is then transferred to a second mold where the black background is injected around the ring and the characters. The numerals cannot wear off and will remain clear cut.

Helical Gear Overlap for Smooth Operation

By R. Howard
British Timken Ltd.
Birmingham, England

IN single helical gears there is a relative change in the angular position of individual sections of each tooth so that, although all sections are similar, successive portions of the tooth are engaged in passing through the contact zone. The lines of contact, instead of running parallel to the gear axis as in the case of spur gears, run obliquely from the tip of the tooth to a point near to the root at the opposite end of the face. Individual portions of the line of contact therefore come into the load zone as the period of tooth engagement progresses. This tooth action provides for the gradual application and removal of the tooth load and results in a quieter and smoother transmission of power.

Fig. 1—For smooth engagement of helical gears, tooth advance should exceed transverse circular pitch



To obtain the maximum benefit from single helical gears it is desirable that each tooth should overlap the other end of the next tooth as shown in the upper view of *Fig.* 1 in which, for a face width F, the displacement or tooth advance is AB. The overlap ratio, R, is therefore

$$R = \frac{\text{Tooth advance}}{p_t}$$

$$= \frac{F \tan \psi}{p_t}$$

where p_t = pitch on transverse section. The normal pitch p_n is more commonly used as it represents the cutter pitch and, since $p_n = p_t \cos \psi$,

$$R = \frac{F \sin \psi}{p_n}$$

where ψ = helix angle. Tooth overlap is therefore a function of helix angle, face width and pitch.

In designing single helical gears overlap should be checked and *Fig.* 2 has been prepared to facilitate this work. Commonly used normal pitches and helix angles are covered by the graph, the maximum helix angle given being 25 degrees since it is not usual to exceed this figure due to the end thrust set up by the axial component of the tooth load, which equals $T \tan \psi$.

EXAMPLE: To secure overlap with a 4-DP gear of 12½-degree helix angle, the chart shows that a minimum face width of 3¾ in. is required.

Lower view in *Fig.* 1 shows chamfering of the tooth ends, which reduces tendency to fracture due to load applications at the unsupported tooth ends X and Y, a point which is of special significance where high helix angles are used to obtain overlap in narrow-face gears.

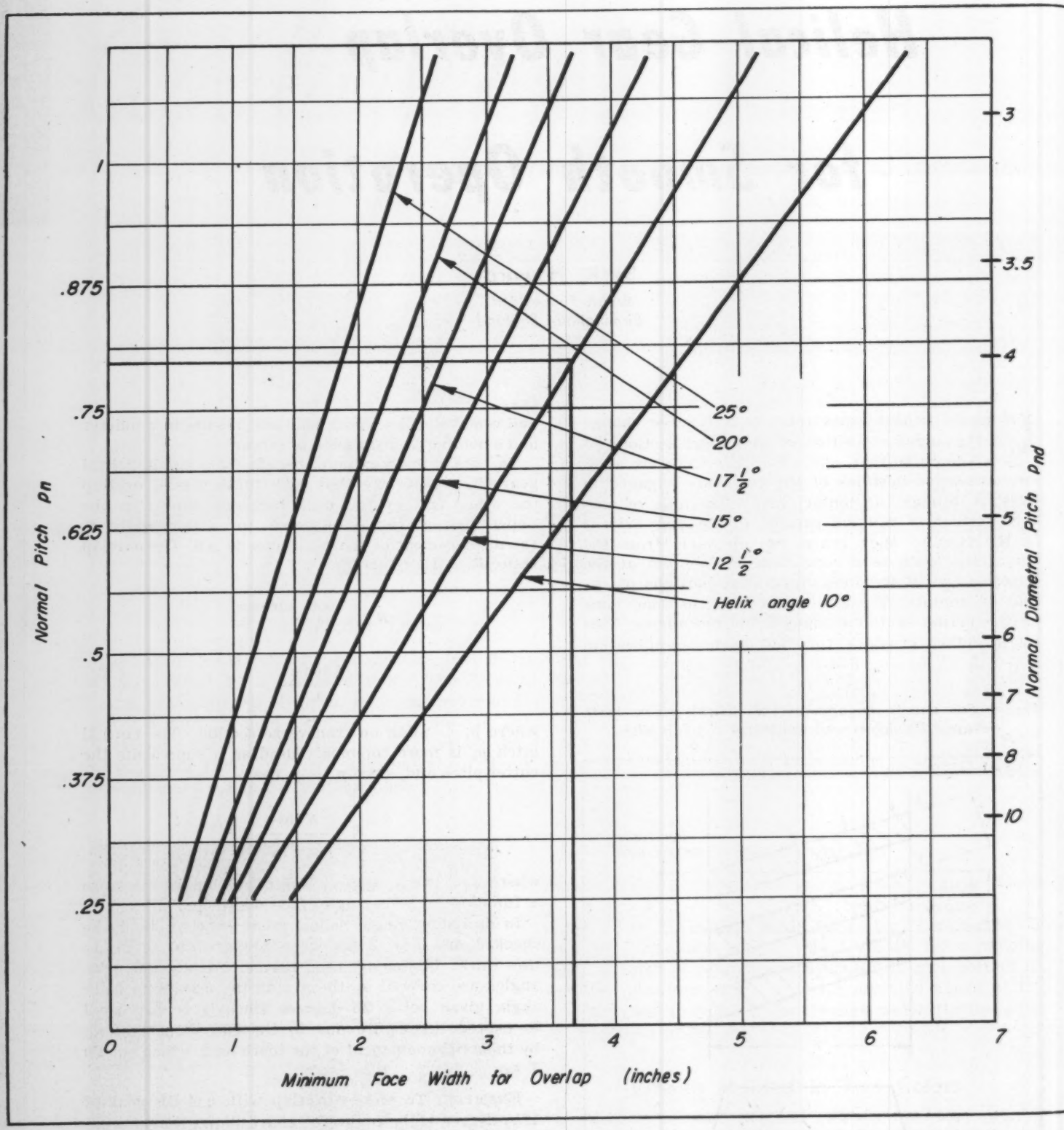


Fig. 2—Chart for determining minimum face width for overlap of single helical gears

new parts and materials

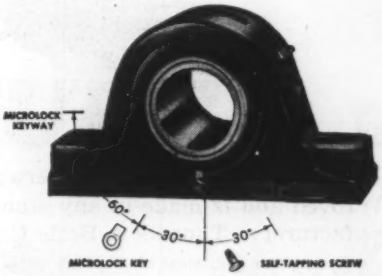
For additional information on these new developments see Page 225

Slide Switches

Two new types of slide switches are suitable for use with low current appliances and equipment. Type SS-26 is a single - pole, single-throw switch and Type SS26-1 is a single-pole, double-throw model. Both are rated at 1 ampere at 125 volts dc, and 3 amperes at 126 volts ac. They are 1⅛-inches long by 17/32-inch wide and are equipped with 11/32-inch black triggers. Colored triggers and terminal enclosures can be supplied. Manufacturer: Stackpole Carbon Co., St. Marys, Pa.

For additional information circle MD 1 on Page 225

Self-Aligning Bearing Units



Features of new line of roller-bearing units include strong housings, self-aligning seals and micrometer bearing adjustments. The floating self - aligning seal is of the Z type and corrects for radial displacement. The Microlock adjustment permits 0.005-inch adjustment steps by means of a screw arrangement. Four types of bearing assemblies available include cartridge unit, flange unit, take-up unit and standard pillow block. Manufacturer: Shafer Bearing Corp., P. O. Box 57, 801 Burlington Ave. Downers Grove, Ill.

For additional information circle MD 2 on Page 225

Dust-Tight Control Center

Standard control units are combined in a heavy steel enclosure to form the class 8938 control center. Control elements such as circuit breakers, starters, master load and control terminal blocks as well as other miscellaneous elements are available. Enclosure types include general purpose, weather resistant and dust tight. Control center is provided with a heavy, reinforced door; handle operates three-point roller-guided locking bars which clamp the door in place. Manufacturer: Square D Co., 4041 N. Richards St., Milwaukee 12.

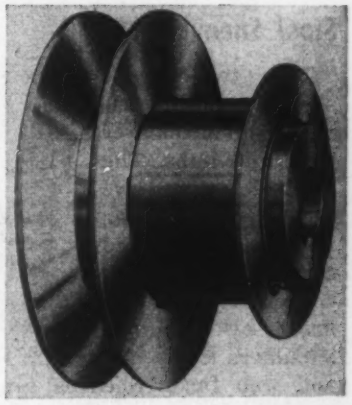
For additional information circle MD 3 on Page 225

Free-Machining Alloy Steel

Machining-time reductions up to 50 per cent have been achieved using Rycut free-machining alloy steel. The alloy develops a hardness comparable to that of AISI 4150 and is available in round, square and flat bar stock. Both annealed and heat-treated stock can be obtained. Manufacturer: Joseph T. Ryerson & Son, Box 8000-A, Chicago 80.

For additional information circle MD 4 on Page 225

Sheave Type Spring Clutches



Ratings from 2 to 5 hp are available in new line of through-sheave V - belt clutches. Shaft on which the clutch is mounted may extend through and beyond the clutch, allowing the drive element to be positioned at any point on the shaft. Features of the line include use of needle roller bearings on the overrunning member, and life lubrication. Clutch has positive on and off positions, the actuator snapping into both positions to eliminate end thrust on bearings. One and two-groove types are available in the larger sizes; shafts accommodated range from ½ to 1⅛ inch in diameter. Manufacturer: L.G.S. Spring Clutch Corp., Indianapolis 6, Ind.

For additional information circle MD 5 on Page 225

Hydraulic Tube Fittings

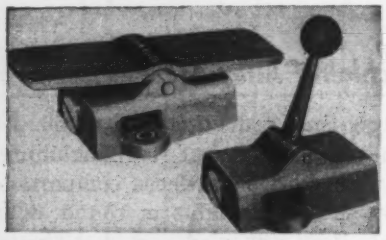
Developed to meet the new JIC standards for hydraulic-circuit connections on production machinery, the Triple-lok tube fitting meets Army-Navy specifi-

cation AN-F-47 for withstanding vibration and impulse. The fitting is steel with dryseal pipe threads and 37-degree flare angle. It is identified by black nuts and sleeves with cadmium-plated body, and will accommodate the complete range of tube-wall thicknesses. Manufacturer: Parker Appliance Co., Cleveland.

For additional information circle MD 6 on Page 225

Pneumatic Control Valve

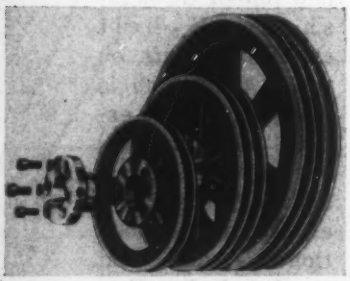
Line of noncorrosive air-control valves includes 3-way (Model HF-3) and 4-way (Model HF-4) types. Made in both hand and foot operated styles, the



valves are of sturdy, compact design especially adaptable for positive accurate control of small single and double-acting cylinders. Either type is made in ¼-inch size. Manufacturer: Airmatic Valve Inc., 1643 E. 40th St., Cleveland.

For additional information circle MD 7 on Page 225

Steel Sheaves

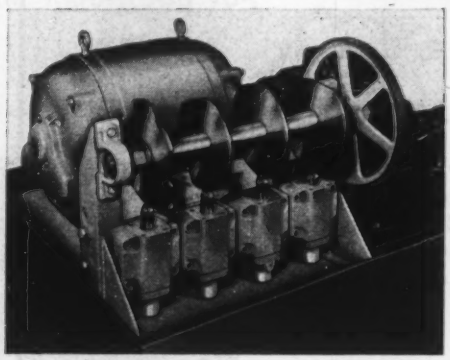


New two-element sheave permits various combinations of rims and hubs. The semisteel rims are secured to the hubs with heat - treated socket-head screws; concentricity is assured by machined shoulders on hub and web face. Sheaves are available in the range 1/3 to 10 hp. They may be obtained with one, two or three grooves for A-section belts and in combination grooves for A and B-section belts, in sizes from 2.2 inch PD to 18.4 inch PD. Manufacturer: Transmission Machinery Corp., P. O. Box 7823, Dallas.

For additional information circle MD 8 on Page 225

Hydraulic-System Time Control

Control for hydraulic systems designated as the Mechanical Brain produces a series of timed signals to control repetitive motions of multiple-cylinder installations. The unit employs a series of cams mounted on a shaft driven by a variable-speed transmission. As the cams rotate they depress roller-bearing followers which actuate control valves. These control flow of hydraulic fluid to the cylinders. Because of the simplicity of the system, sequence cannot get out of time and maintenance is reduced to a minimum. Cams are designed to suit requirements;

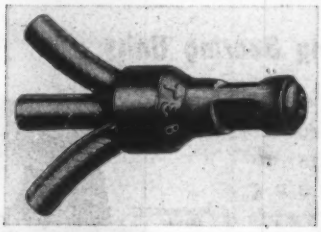


number of cams on shaft can be varied to suit the needs of the installation. Manufacturer: Hufford Machine Works Inc., Redondo Beach, Calif.

For additional information circle MD 9 on Page 225

Solderless Connector

Solderless wire connector, designated No. RB-4, consists of high-strength high-dielectric insulation molded around a seamless bronze barrel. Design permits complete connection and insulation of wiring in

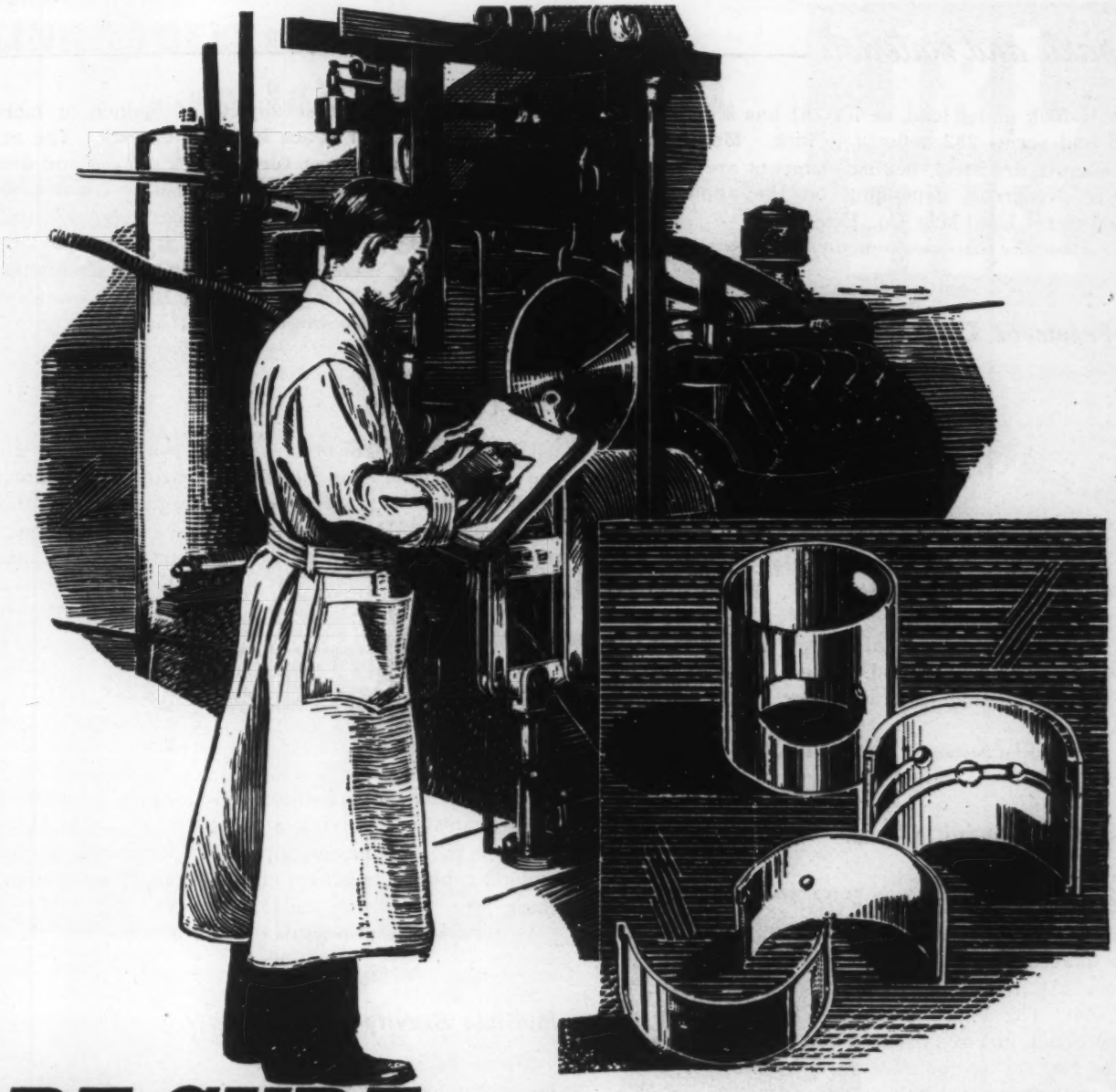


one operation. Unit is Underwriters Laboratories approved and is made in any standard code color. Manufacturer: Thomas & Betts Co., Elizabeth, N. J.

For additional information circle MD 10 on Page 225

Snubbing Vibration Mounts

Frequencies from 700 cpm upward can be isolated with new snubbing vibration mounts. The units are designed to control severe shock, and have snubbing shoulders which act against steel washers when impact occurs. Load capacity is from 120 to 310 pounds. Three types of mounts are available: Series 279 has a deflection



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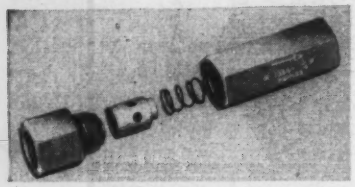
JOHNSON BRONZE CO.

525 S. Mill St., New Castle, Pa.

limit of ⅛-inch under load, series 281 has a deflection of 3/16 and series 282 deflects ¼-inch. Metal parts of the mounts are steel, flexing elements are natural rubber or Neoprene, depending on the application. Manufacturer: Lord Mfg. Co., Erie, Pa.

For additional information circle MD 11 on Page 225

Hydro-Pneumatic Check Valve



Small, lightweight check valve is suitable for use with oil, water, gas and air. The unit, known as K-1354, is designed for operating pressures to 3000 psi and temperatures from −65 to 160 F. It is tested at 7500 psi. Sizes available are ⅛, ¼, ⅜, ½, ⅝, ¾ and 1 inch. Internal and external pipe or tubing connections can be provided and bodies are aluminum, stainless steel or Monel. Manufacturer: Kohler Co., Kohler, Wis.

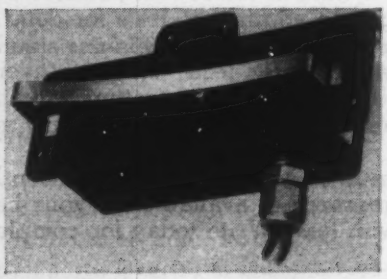
For additional information circle MD 12 on Page 225

Low-Pressure Conduit Clamp

Suitable for use with flexible conduits, the Flexfast low-pressure clamp is made in sizes to accommodate tubing from 1½ to 37 inches in diameter. The device is a one-time clamp and requires no tools for set up or release. Tightening means consists of an overlapping, one-piece, nonrusting metal clamping band with a strap and buckle take-up. Unit is constructed of three parts integrated into a single unit. It is said to be particularly suited for use under severe service conditions. Manufacturer: Flexible Tubing Corp., Branford, Conn.

For additional information circle MD 13 on Page 225

Splashproof Actuating Switch

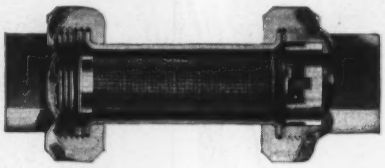


For use with electric counters, new actuating switch is recommended for applications where it is apt to come in contact with water or other liquids. Switch is housed in a sturdy cast-aluminum, gasketed case; fittings for waterproof cable provide splashproof electrical connection. The actuating arm is nickel silver, shaped to count circular objects of ¾-inch or more in diameter without space between objects. The actuation requires a direct force of 4.2 ounces and arm must be depressed 3/32-inch for positive counter actuation. Dimensions are: 6-inches long, 1⅞-inch wide and 1 9/16-inch deep. Base is provided with eight mounting holes. Manufacturer: Production Instrument Co., 702-08 W. Jackson Blvd., Chicago 6.

For additional information circle MD 14 on Page 225

Flow-Control Unit

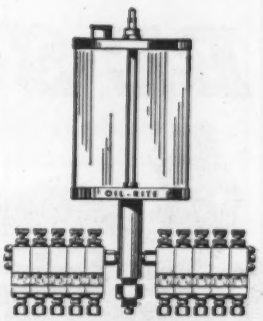
Usable for control of the flow of water, gas or air, the Mesurflo control unit automatically measures predetermined rate of fluid flow regardless of variable pressure. It also subdues excess pressure hammer and eliminates surge. The control can be used



in conjunction with a timing mechanism to measure fluid quantities. Having an included Straitflo Monel strainer, the unit has a copper body, bronze couplings, molded rubber diaphragm and gaskets. Manufacturer: Hays Mfg. Co., 12th and Liberty St., Erie, Pa.

For additional information circle MD 15 on Page 225

Multiple Gravity-Feed Oiler



Up to 24 components can be lubricated automatically and simultaneously by the Oil-Rite multiple oiler. Unit has single reservoir and common shut-off lever. However, oil feed to each bearing can be adjusted. Control lever actuates a needle valve which releases oil to the sight feed valves. Drop feed at each valve allows independent regulation from full flow to complete shut off. Oilers have aluminum alloy bodies, and transparent plastic reservoirs. Glass reservoirs can be provided for higher temperature application. Manufacturer: Oil-Rite Corp., Milwaukee, Wis.

For additional information circle MD 16 on Page 225

Snap Nut for Blind Locations

Threaded fasteners for use in blind locations are pressed into prepared holes in sheet metal to serve as nut plates. Units, known as Snap Nuts, are made of spring steel and will accept either No. 8 or No. 10

LINK-BELT makes more and better sprockets
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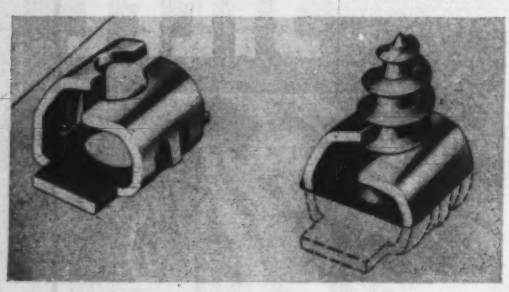
sheet metal screws. Arched spring arms of the nuts expand to permit entry of the screw and then bind against the thread root to hold against vibration. No special tools are required to insert these fasteners;



they are hand inserted into previously prepared 9/32-inch square holes in panels. Manufacturer: Prestole Corp., 3137 Bellevue Road, Toledo 6, Ohio.

For additional information circle MD 17 on Page 225

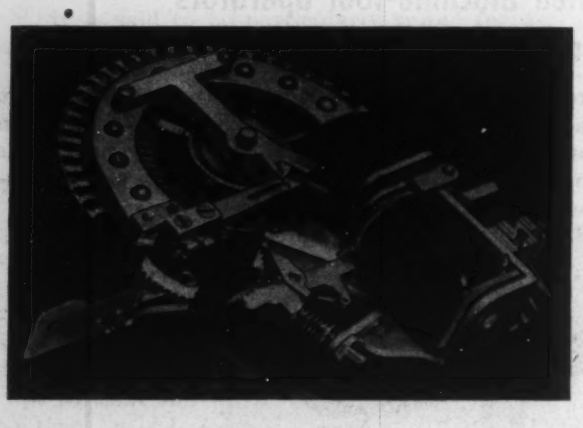
Heavy-Duty Clutch-Driven Pumps

Line of clutch-driven pumps are made in capacities up to 300 gpm and pressure ratings to 25 psi. They are designed for use with 1½ and 2-inch pipe. Model 3800 is a high-efficiency centrifugal pump available in clockwise and counter clockwise types. Model 3841 is reversible; model 3840 is self priming with a suction lift of 20 ft. Feature of the line is the use of a heavy disk clutch on the impeller shaft. Manufacturer: Marine Products Co., 515 Lycaste St., Detroit 14.

For additional information circle MD 18 on Page 225

Automatic Rotary Stepping Switch

Features of type 45 automatic stepping switch are high-speed operation, dependability and simplicity of adjustment. This 25-point switch is adaptable to a



wide variety of electrical control requirements calling for the remote selection of circuits by means of either external pulsing or self-pulsing control. The switch can have up to 15 banks of 25-point contact levels, single-ended contact brushes can be supplied to provide up to 50 outlets. When equipped with 10 contact brushes the switch can be adjusted to operate at speeds up to 70 steps per second when self-pulsed, or up to 35 steps per second with external pulsing. Both conditions are for 46-volt, dc operation. Manufacturer: Automatic Electric Co., 332 S. Michigan Ave., Chicago 4.

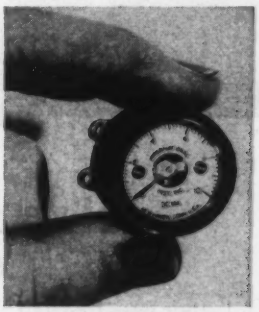
For additional information circle MD 19 on Page 225

Automatic Friction Clutch

Rating of new automatic clutch is 5 hp at 2000 rpm. The unit, which is recommended for use on both portable and fixed industrial apparatus, is mechanically balanced, self-actuated in either direction of rotation and has the same characteristics in both directions. It may be mounted on horizontal or vertical shafts and is equipped with a combination sheave for use with A or B type V-Belts. Shaft diameters suited range from ½ to 1 inch. The C-1000 clutch measures 4⅜ inches in diameter and 2½ inches long. Manufacturer: Clark Clutch Div. of All Steel Welded Truck Co., Rockford, Ill.

For additional information circle MD 20 on Page 225

Miniature Electric Meter



Milliammeter for use in conjunction with test equipment, aircraft controls, etc., measures 1 inch in diameter and has a scale arc of 270 degrees. Long scale arc has a chord greater in length than that of conventional 3½ inch meters. The instrument operates on the D'-Arsonval principle, using a moving coil. Movements, however, are unusually light in weight and attain an accuracy of ±2 per cent. Meter is sturdily constructed to withstand vibration and shock and can be made watertight. It is mounted by means of a threaded ring, eliminating the need of drilling mounting holes and permitting sealing of the meter to the instrument panel. Manufacturer: International Instruments Co., 331 East St., New Haven 11, Conn.

For additional information circle MD 21 on Page 225

Rotary Switches

Underwriters Laboratory listed rotary switches are available in multipole, multistage detent types. Covered are 4, 8 and 16-positon switches in one to forty

Fluid Power

IN A PACKAGE

the New Hydro-Sheave Drive

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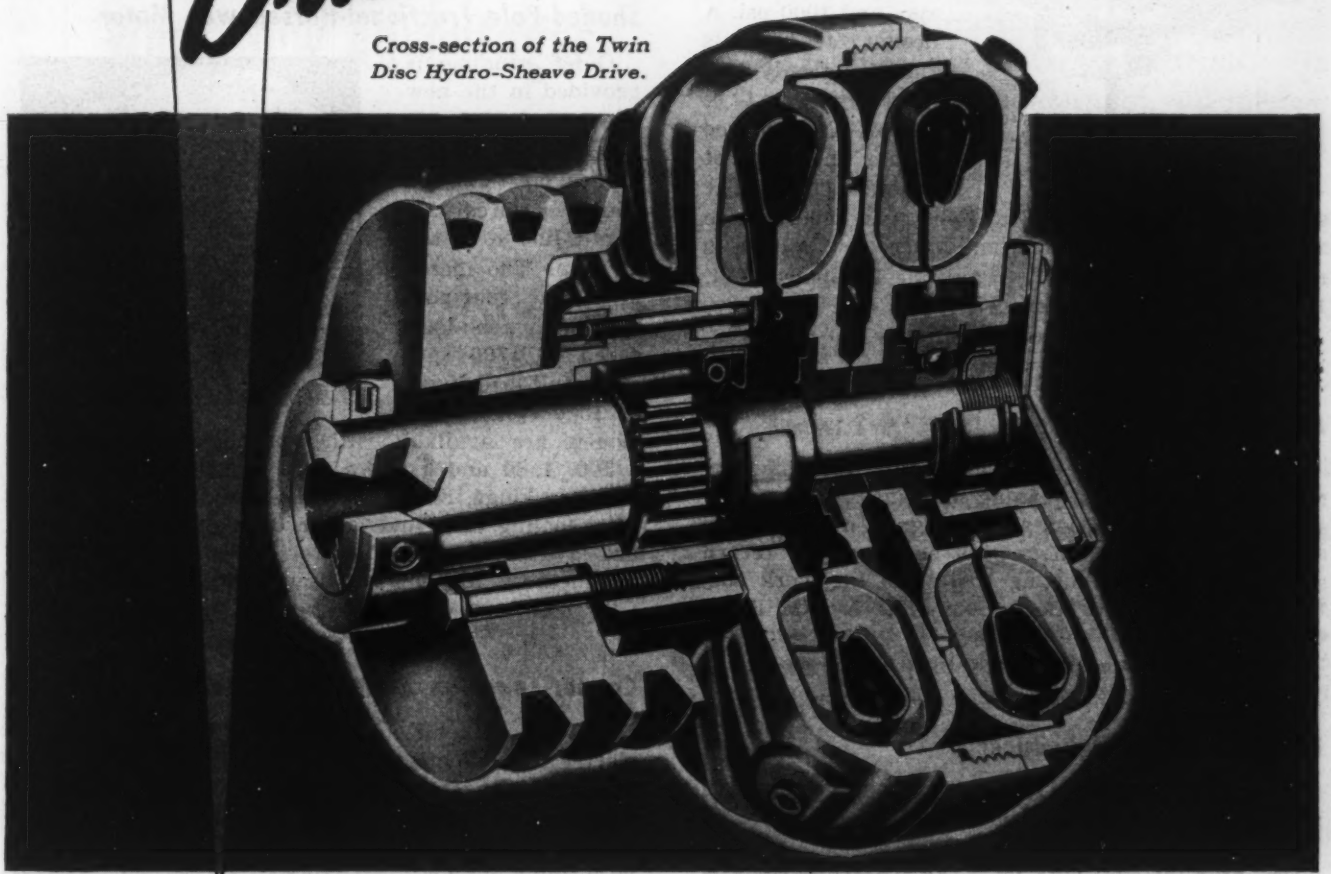
Twin Disc Hydro-Sheave Drive offers the operator of small power units all the advantages of a fluid drive in a low-cost conversion device no more difficult to apply than a sheave. The sleeve of the Hydro-Sheave slides over the output shaft of your power unit where it is held in place by three set screws. The package is complete with installation instructions, parts drawings, parts list and the wrench required for mounting.

Designed especially for use with Worthington QD sheaves on electric motors and small internal combustion engines in the ¾ to 25 hp range, Twin Disc Hydro-Sheave Drive is available in five sizes. For complete information, including price and the name of your nearest distributor, write the Hydraulic Division for a copy of Bulletin 145. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

Cross-section of the Twin Disc Hydro-Sheave Drive.



TWIN DISC
HYDRO-SHEAVE DRIVES

SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

pole combinations. Electrical ratings are 10 amperes, 125 volts; and 5 amperes, 250 volts ac. Base and panel mountings are available. Manufacturer: Electro Switch Corp., 193R Broad St., Weymouth 88, Mass.

For additional information circle MD 22 on Page 225

Hydraulic Gear Pumps

Series 100 oil hydraulic gear pumps, tradenamed Four Bolt, are made with flange and foot mountings. Both types are available in two capacities: 2.25 gpm at 3000 rpm and 1000 psi, and 4.5 gpm at 3000 rpm and 1000 psi. A design feature is the use of only four assembly bolts; these are placed within the area of greatest stress. The series has been designed for applications where there are rigid space restrictions and where low volume is required. Manufacturer: Hydraulic Equipment Co., 1100 E. 222nd St., Cleveland 17.

For additional information circle MD 23 on Page 225

Automatic Tool Lifter

Electomagnetic tool lifter is suitable for incorporation in shaping and planing machines. Device consists of three components: A magnet, a switch and a transformer. The magnet is energized on return strokes, lifting the cutting tool from the work surface. Manufacturer: Deca Co., 4 N. Avalon Road, Great Neck, N. Y.

For additional information circle MD 24 on Page 225

Worm-Gear Speed Reducer

Features of the type TAN speed reducer are the use of heavy gearing and of a worm gear integral with its shaft. Replacing the type TA reducer, the new model has the same mounting dimensions and shaft centers. Shaft sizes, however, are increased, permitting greater loads. Other improvements include large one-piece housing to provide heat-radiation area, and a new vent valve which keeps out foreign matter, while permitting the unit to breathe. In addition, improved oil seals minimize oil leakage and reduce friction at the shaft. Reduction ratios covered by the reducer units range from 10:1 to 80:1, with corresponding horsepower outputs at 1800 rpm input of 1¼ and 5/32. Torque outputs at the same ratings are 437 and 456 lb-in., respectively. Manufacturer: Boston Gear Works, Quincy 71, Mass.

For additional information circle MD 25 on Page 225

Screw-On Wire Connector

Over 25 combinations of No. 16 and No. 18 stranded or solid electric wire can be spliced using the No. 1 midget Screw-On wire connector. Requiring no soldering or special tools the connector provides a secure and rapid installation. Overall length of the unit is ⅝-inch. Manufacturer: Holub Industries Inc., Sycamore, Ind.

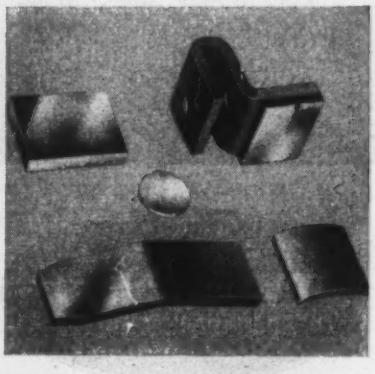
For additional information circle MD 26 on Page 225

Shaded-Pole Fractional-Horsepower Motor

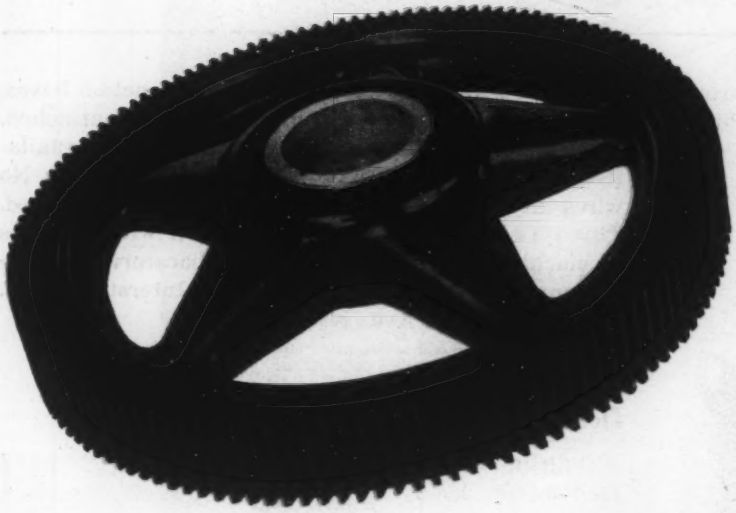
Quiet running is provided in the new Electro shaded-pole motor by a single-bearing design which assures accurate line-up of the air gap. The motor is of the four-pole type with a no-load speed of 1700 rpm and a full-load speed of 1550 rpm. Three models are available with continuous duty ratings 1/100, 1/80 and 1/60-hp with ¾, 1¼ and 1¾ inch core stackings, respectively. All models are provided with cooling fans and either open or covered styles are available. Manufacturer: Electro Engineering Products Co. Inc., 4824 W. Kenzie St., Chicago 44.

For additional information circle MD 27 on Page 225

Copper-Tungsten Electrical Contacts



Powder - metal electrical contacts of copper-tungsten will interrupt heavy currents with minimum corrosion. They are recommended for use in oil and air-immersion contacting and for arcing applications. Made of Gibsiloy UW6, the contacts have a hardness of 90 Rockwell B, conductivity of 50 per cent IACs, and cross breaking strength of 135,000 psi. One surface is coated with



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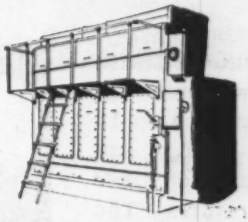
And *Celoron* is but one of many C-D materials that can help to add new advantages to your product. Whatever your application, see Continental-Diamond first for recommendations that lead to higher product quality and appearance . . . lower fabrication costs. Your nearest C-D office has trained technicians with additional information that will interest you. Call or write, any time.



Another C-D Case of Improved Performance

Making a huge, 2-foot timing gear for Diesel Locomotives always presents problems. The gear had to be strong enough to stand terrific strains —yet resilient enough to absorb shock. Dimensional stability, quiet performance, and easy machining were basic requirements. *Celoron* is proving its ability on applications like this, and a host of others where mechanical precision and rugged operation are needed.

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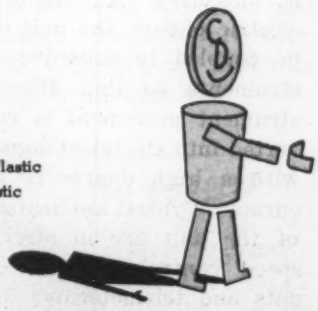
VULCOID—Resin Impregnated Fibre
DILECTO—Laminated Thermosetting Plastic
CELORON—Molded High-Strength Plastic
MICABOND—Bonded Mica Splittings

DM-4-48



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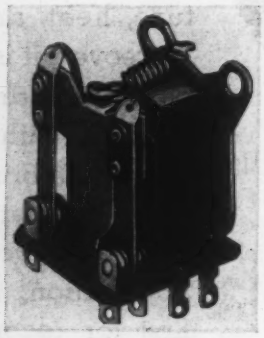
Continental-Diamond FIBRE COMPANY

Established 1895 . . Manufacturers of Laminated Plastics since 1911 — NEWARK 23 DELAWARE

silver solder to facilitate brazing. Manufacturer: Gibson Electric Co., 8355 Frankstown Ave., Pittsburgh 21.

For additional information circle MD 28 on Page 225

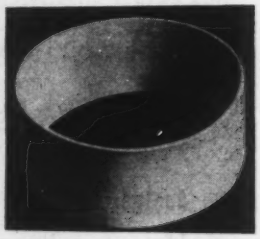
Miniature Magnetic Relays



Bulletin 102 magnetic relays are designed for automatic and remote control circuit applications where space is limited. Measuring 1⅛ inches high, 1⅝ inches long and 1 inch wide these control elements are suitable for operation on 115-volt 60-cycle and 32-volt dc circuits. Features include silver-to-silver, self-cleaning contacts, low power consumption, solder type terminals and 3-ampere, 115-volt contact rating. Manufacturer: Ward Leonard Electric Co., Mount Vernon, N. Y.

For additional information circle MD 29 on Page 225

Glass-Reinforced Silicone-Rubber Sleeving

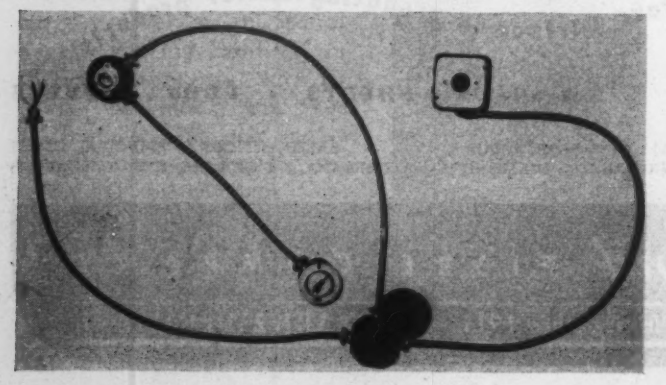


Flexible sleeving of silicone rubber reinforced with Fiberglas will withstand internal pressures of 5 to 10 pounds without leakage, and permit the passage of gases at high temperatures. The material will withstand 500 hours of continuous service at 400 F and five hours at 450 F. It will remain flexible at temperatures as low as minus 75 F. Manufacturer: Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.

For additional information circle MD 30 on Page 225

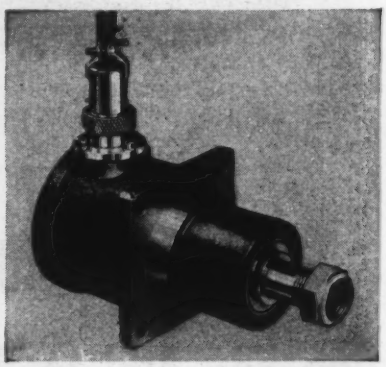
Armored Wiring Harnesses

Custom-designed wiring harnesses are made with either rigid or flexible steel-clad conduits. The assemblies are complete with all wiring in precut conduits and with all necessary terminals, junction boxes, switches, relays, sockets and other fittings attached. The entire wiring system is ready for quick installation in the equipment for which it is intended. No wires need be cut and no parts need be attached. This type of harness is suitable for use with all types of machines where Underwriters Laboratories require armored wiring. Manufacturer: Interstate Mfg. Corp., 138 Sussex Ave., Newark 4, N. J.



For additional information circle MD 31 on Page 225

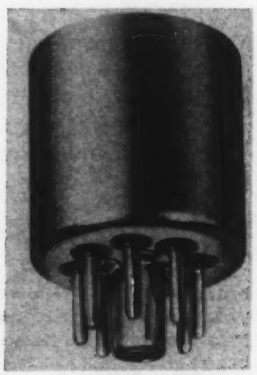
Electric Tachometer



Built-in electric tachometer has excellent performance over a wide range of speeds and is said to be virtually free from the effects of stray magnetic fields. The instrument measures 2¾ by 5⅜ inches, has a cast-bronze case and is equipped with a large driving shaft. The unit, identified as Model M-1200, is recommended for applications where size precludes the use of larger and heavier types. Manufacturer: The Electric Tachometer Corp., 2218 Vine St., Philadelphia 3.

For additional information circle MD 32 on Page 225

High-Sensitivity Synchro Transmitter



Suitable for transmitting signals from low-torque outputs, the Synchrotel synchrotransmitter can be used where high accelerations and rapid oscillations are to be measured. An inductive electric pickup, the unit can be coupled to sensitive instruments so that the instrument movement is converted into electrical signals with a high degree of accuracy. Typical applications of the unit are in aircraft speed controls for automatic pilots, computor inputs and telemetering. Manufacturer: Kollsman Instrument Div., Square D. Co., Elmhurst, N. Y.

For additional information circle MD 33 on Page 225

Medium-Pressure Fluid Pumps

Gear type liquid pumps, suitable for use in delivering pressures up to 200 psi, have stainless-steel drive gears and graphite driven gears. Bearings are graph-

100 horsepower Century motor driving
a 60" grinding wheel and...
25 horsepower motor driving a hydraulic
drive on a surface grinder.

100 H. P. Century MOTOR—Driving a 60" Grinding Wheel Provides a Smooth Production Combination

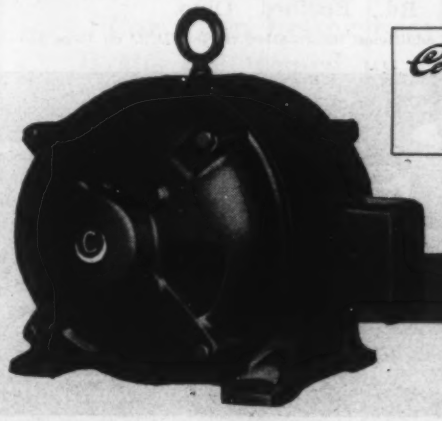
This 100 H.P. Century Motor operating a huge 60" surface grinder and the 25 H.P. Century motor operating the feeder mechanism, is one of the hundreds of thousands of Century drives used in the precision production industries.

The unusual freedom from vibration designed and built into Century motors, contributes to the precision grinding at the business end of the grinder that was intended by the manufacturer of this fine tool.

The rugged mechanical design of Century motors are suitable not only to precision applications like this but also for the heavy shock loads required in some industrial operations.

From Century's wide range of types and kinds of motors, in sizes from 1/6 to 400 horsepower, you can select the correct motor to meet the exact requirements of your machines. The properly selected Century motor on your machine tools, conveyors, processing machinery, etc., helps to increase productivity, keep maintenance costs low and reduce plant shutdowns caused by improperly applied motors.

Specify Century motors for all of your electric power requirements.



Century C MOTORS

Popular types and ratings are generally available from factory and branch office stocks

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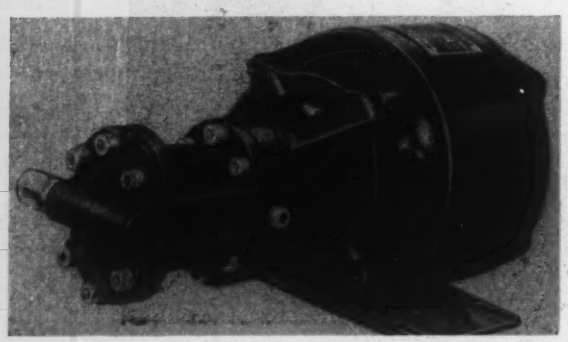
-608

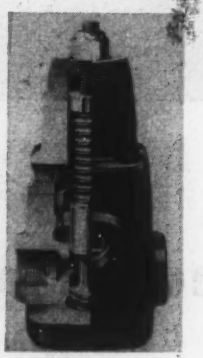
ite-impregnated carbon. Metal-to-metal contact has thereby been eliminated and friction reduced to a minimum. The pumps are made in two models: Type GW-1, rated at ½ gpm and GW-2 rated at 1 gpm. The units are available with 1/6 or ¼-hp integral



motors, or fittings for belt or flexible coupling drives. Manufacturer: Eastern Industries Inc., 296 Elm St., New Haven 6.

For additional information circle MD 34 on Page 225

Hydraulic Relief Valve



Chatter-free performance is the outstanding characteristic of a new hydraulic relief valve. The chattering of the valve is eliminated by a dash-pot arrangement. Features are pressure ports which permit an in-line piping arrangement and valve springs in two sizes for 50-300 and 50-1500 psi service. Hand wheel adjustment can be provided, this type of valve using an O-ring seal. A self-sealing locknut eliminates lost valve caps. Manufacturer: Gerotor May Corp., P. O. Box 86, Baltimore 3.

For additional information circle MD 35 on Page 225

Insert Injection Moldings

New plastic injection process permits the molding of parts onto tape, wire, chain, etc. The automatic process accurately spaces the parts and can mold with alternate colors or with "jump" spaces. Maximum size of each plastic element is 1¼ inches long and maximum weight is 0.03-ounce. Manufacturer: Gries Reproducer Corp., 780 E. 133rd St., New York 54.

For additional information circle MD 36 on Page 225

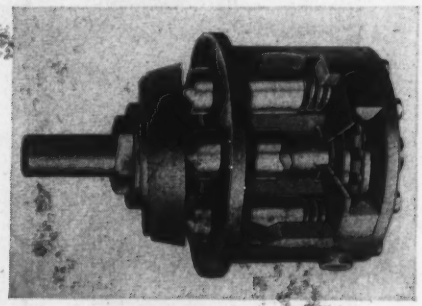
Thermal Insulation

Plastic coating compound, appliable by brush, trowel or extrusion gun, insulates against temperatures as high as 2800 F. The material, designated Stabond FR 10, has been tested by application of a ⅛-inch coating to an oil tank and exposure to 2000 F flame blast for 36 minutes, without damage to the underlying metal. A similar material know as Stabond FR 8 is suitable for applications having lower service temperatures. Manufacturer: American Latex Products Corp., 921 Venice Blvd., Los Angeles 15.

For additional information circle MD 37 on Page 225

Hydraulic Pump

Piston type hydraulic pump operates on the nutating plate principle and has a rotary valve. By the use of this "wobble plate" the only revolving part is the driveshaft assembly and side thrust is virtually



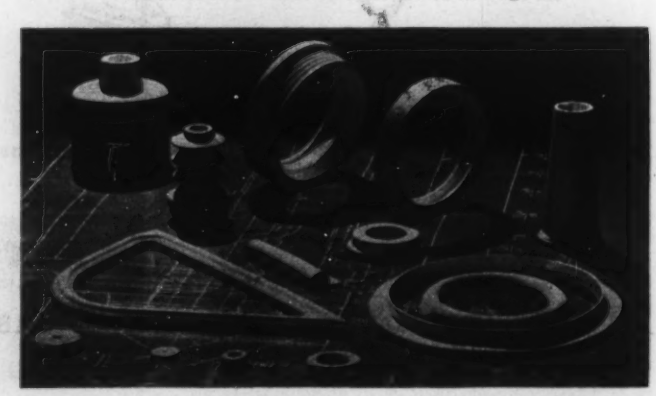
eliminated. The pump will operate in either direction and is compact and light in weight. Rotary valve is full floating and hydraulically balanced. Manufacturer: Eastman Pacific Co., 2320 E. 8th St., Los Angeles 21.

For additional information circle MD 38 on Page 225

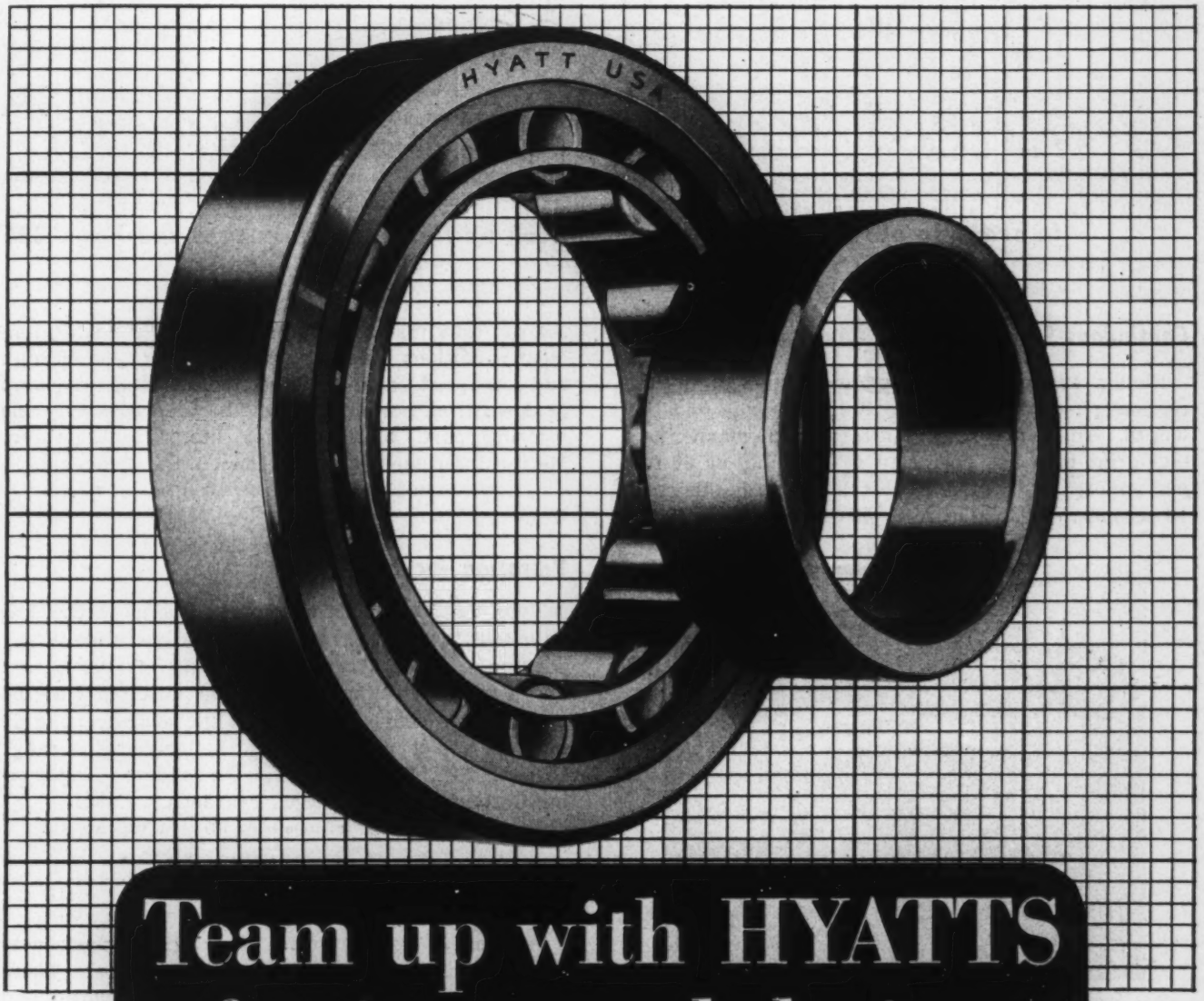
Silicone Extruded and Molded Parts

Line of extruded and molded silicone rubber parts are designed to meet the demand for high temperature parts having resilience at temperature extremes. Such components as gaskets, diaphragms, grommets, washers, seals, packings, etc., retain rubber-like properties at temperatures from −150 to 500 F. The material will not become hard and brittle and will not crack after long exposure to air, ultraviolet rays or ozone. Typical applications include ovens, engines, electric heating equipment, and die casting machines. Manufacturer: Stalwart Rubber Co., 180 Northfield Rd., Bedford, Ohio.

For additional information circle MD 39 on Page 225



Wichita City Library



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IT'S not uncommon to find Hyatt Roller Bearings outlasting the machines and equipment for which they were selected.

For when better bearings like Hyatts are teamed up with better product design exceptional performance is to be expected.

With so many sizes and types of Hyatts to choose from—and with our many years of application experience at your service—we believe we can help you to keep your products always ahead of the procession, if given the opportunity to demonstrate. Put your problem up to the nearest Hyatt office. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J., Chicago, Detroit, Pittsburgh and Oakland, Calif.

HYATT ROLLER BEARINGS

engineering dept equipment

In order to obtain additional information on this new equipment see Page 225

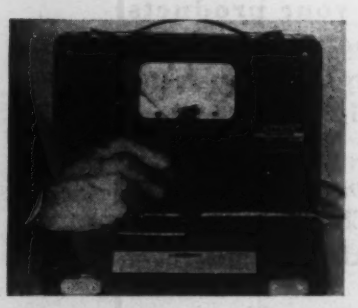
Continuous-Strip Microfilm Camera

Flofilm 42-inch microfilm camera can make a continuous photograph of copy 42-inches wide and any length. The unit is fed in much the same manner as a blue-print machine, operating at either 30 or 60 feet per minute; a drawing 10 feet long can be filmed in 10 seconds. Reduction ratio of 34 times reduces the

microfilm image to less than 1/1000th the area of the original copy. Through use of an enlarging feature, the image can be then printed at original or enlarged size on a single sheet or roll of paper in one printing operation. Manufacturer: Diebold Inc., 2 W. 45th St., New York 19.

For additional information circle MD 40 on Page 225

Electric Tachometer



High - precision electric tachometer is accurate to ¼ per cent of the speed being measured. Two styles are available, type 48J, for speeds from 90 to 1000 rpm, and type 48H for speeds from 900 to 10,000 rpm. Each has ten overlapping ranges selectable by means of a rotary switch, no damage is incurred by accidental selection of the wrong range. The instruments employ an electrical bridge circuit principle and are calibrated by matching against internal precision resistors, thus insuring readings against changing ambient conditions. They can be used with type 46 high and low-speed adapters to shift measuring ranges up or down from normal ranges. The head uses only one rotating part, lubricated for life. Manufacturer: Metron Instrument Co., 432 Lincoln St., Denver 9.

For additional information circle MD 41 on Page 225

Vibration Pickup

Type 4-402 vibration pickup requires no mechanical adjustments or special calibration for operation in any position. It has a sensitivity of 110 mv per in. sec and a frequency response which is flat from 7 to 700 cps, ±7 per cent. Damping in the instrument is 64 per cent and it may be used in the temperature range 15 to 212 F. Manufacturer: Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena 4, Calif.

For additional information circle MD 42 on Page 225

Lettering Instrument

Instrument for lettering of drawings reproduces characters engraved in a master template. These characters can be reproduced to variable widths and heights from 0.075 to 0.75-inch. Width and height are separately controlled by adjustment knobs. Resting on the surface being lettered, the instrument, which is known as the Varigraph, slides against a straightedge as it is moved from one letter position to the next. The template, carried by the instrument, slides to the position required to align the next character. For reproduction, a stylus is travelled around the template groove, the pen then reproducing the letter to the desired scale. Manufacturer: Varigraph Co., Inc., Lincoln, Nebraska.

For additional information circle MD 43 on Page 225

FELTS IS USED IN EVERY CAR IN EVERY AUTOMOBILE FACTORY

Lubrication — Sealing — Insulating — Cushioning — Anti-Rattle
Anti-Squeak — Sound Absorption — Polishing — Silencing — Washers
Gaskets — Liners — Channels — Weatherstrip — Packing — Filtration

1 FAN BEARING OILER. 2 WATER PUMP PACKING AND OILER. 3 GENERATOR BEARING SEALS. 4 GENERATOR AND STARTER LUBRICATING WICKS. 5 OIL FILTER. 6 BATTERY POSITIVE TERMINAL ANTI-CORROSION WASHER. 7 BRAKE BOLT OILER. 8 STEERING KNUCKLE TO TIE ROD DUST SEAL AND FLANGE JOINT SEAL. 9 STEERING ARM BEARING OILER. 10 FRONT WHEEL BEARING SEAL. 11 WHEEL BRAKE SHOE OILER. 12 CARBURETOR. 13 STEERING COLUMN GROMMET. 14 TRANSMISSION OIL SEAL WASHER. (SEAL ASSEMBLY TRANSMISSION BEARING). 15 DRIVE SHAFT DUST SEAL. 16 TOE BOARD AND FLOOR BOARD LINER. 17 CLUTCH HOUSING PAN DUST SEAL. 18 BODY TO CHASSIS STRIPS. 19 WINDSHIELD WIPER PIVOT ARM MOUNTING. 20 WINDOW LIFT LUBRICATORS. 21 DOOR PANEL INSULATOR. 22 FLOOR BOARD PARTS. 23 UNIVERSAL OIL SEAL. 24 TURRET TOP INSULATION. 25 WINDOW RUN CHANNEL. 26 REAR AXLE DRIVE SHAFT SEAL. 27 AXLE PINION DRIVE BEARING SEAL. 28 UPHOLSTERY RISER STRIPS. 29 SPRING COVER LINING. 30 REAR PANEL WEATHERSTRIP. 31 FUEL TANK STRAP GASKET.

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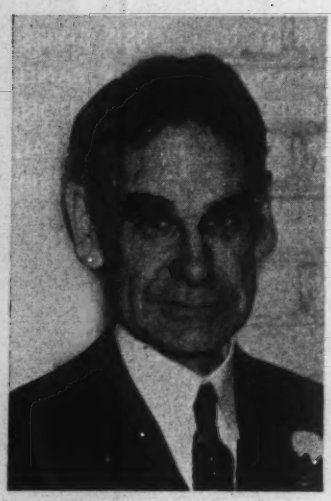
Some Additional Applications of Felt: Clutch release link lever oiler • Window anti-squeak • Fuel tank support lining • Brake shoe anchor pin washer • Drag link dust cover • Intermediate steering arm bearing seal • Windshield wiper motor washer • Toe and floor board anti-squeak • Solenoid cover gasket • Heater core to housing filler • Spindle bolt grease retainer • Spindle bolt dust washers • Radius rod felt • Hydraulic lift spring seat • Door bumpers • Pedal pads and seals • Dash liners • Oil retainers • Polishing felts, for glass, metal and paint • Door liners • Ventilator valve seals • Weather seals • Hood lace filler • Moulding shim • Timing gear cover pad • Accelerator rod pad • Fuel tank shim • Propeller shaft spline oiler • Paint filter bags • Crankcase oil filter cap • Brake dirt seals • Defroster control valve seal • Hand brake cable clamp seal • Windshield division filler • Pinion bearing retainer packing • Horn wire locator felt • Oil sabre dust washer • Fender welt felt • Spring oiler felt • Spring bumpers • Gas filling protector pads • Rocker arm seals • Chafing strips for convertible tops • Upholstery padding • Radio selector pads • Thrust bearing inserts • Cab roof lining • Antenna weather seal • Blankets for protection during assembly and service • Factory table pads • Glycerine pads for windshield wipers •

MEN...of machines



E. W. Miller

Warren E. Wilson

E. W. MILLER was recently appointed president of the Fellows Gear Shaper Co. on the day following his completion of 50 years service with the company. Mr. Miller began his engineering career as an apprentice in 1898, was made a draftsman in the engineering department three years later and in 1914 was appointed chief engineer. In 1939 he became general manager of the company and in the same year was elected to the board of directors. A vice president of the company at the time of his elevation to his present position, Mr Miller has been instrumental in creating the designs for many types of equipment for cutting, finishing and testing of gears, as evidenced by the many patents in his name. He is a prominent member of the American Gear Manufacturers Association, serving as president from 1932 to 1934. He is the author of numerous articles on gear design, and during the first World War was on the transmission committee of the Society of Automotive Engineers. In 1942, Stevens Institute of Technology conferred the honorary degree of mechanical engineer on Mr. Miller for his outstanding contributions to the engineering profession. He is an active member of the American Society of Mechanical Engineers and the Council for Technological Advancement of Machinery and Products Institute. Mr. Miller is also president of Vermont Foundries Inc.

WARREN E. WILSON, formerly director of research of the hydraulics division of Sundstrand Machine Tool Co., has been appointed president of the South Dakota School of Mines and Technology. Previously, Dr. Wilson was active as a consultant in industrial hydraulics and as chairman of the department of fluid mechanics at the Armour Research Foundation. His teaching career began in 1935 at the school to which he has now returned as president and included his serving as head of the department of mechanics at the Colorado School of Mines. He is a member of numerous engineering and scientific societies and is chairman of the American Society of Mechanical Engineers committee on hydraulic power transmission. Dr. Wilson has contributed to MACHINE DESIGN, his latest article being "Hydraulic Pumps and Motors" in this issue.

THOMAS D. JOLLY, vice president in charge of engineering and purchases of the Aluminum Co. of America, has recently been elected president of the American Standards Association. Mr. Jolly began his career with Alcoa as a draftsman for the New Kensington works of the company in 1915, after he had learned the machinist's trade as an apprentice in the Pennsylvania Railroad shops at Verona, Pa. During his 31 years with the Aluminum Co., he has served as drafts-

Thomas D. Jolly

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1

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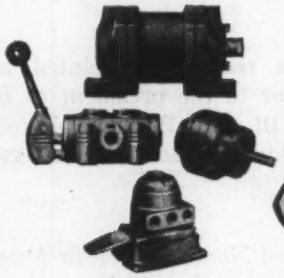
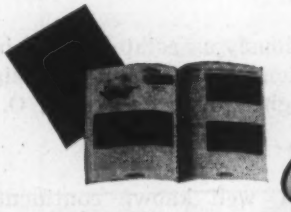
Gerotor service is featured by the engineering assistance of its factory trained distributors. These men are qualified from long experience to handle any air and hydraulic problem. Located in all principal cities, they can assist in laying out the circuit best suited to your operating requirements and recommend the correct equipment to provide long years of satisfactory operation.



2

The Complete GEROTOR Line

Gerotor can furnish the exact model valve, cylinder and pump to meet individual requirements. For example—Gerotor 4-Way Hydraulic Valves are offered in 50 models with 4 types of action—standard, spring return, spring centered and ball detent; 5 piston designs; 6 types of operation—hand, foot, cam, solenoid, oil and air pressures; 7 sizes—¼", ⅜", ½", ¾", 1", 1¼" and 1½".



3

Informative Literature

The 100-page Gerotor Catalog describes every detail of hydraulic and air valves, cylinders, pumps, pump units. It represents the most thorough presentation of hydraulic and air devices that long experience in this field can prepare. If you do not have the new Gerotor Catalog in your file for reference and assistance, write for your copy today.

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man, master mechanic, and superintendent of maintenance at the New Kensington works; superintendent of the Arvida plant; and as buyer and purchasing agent in the Pittsburgh office of the company. Mr. Jolly became chief engineer and director of purchases in 1937 and was made vice president in charge of engineering and purchases in 1942. During the war he was in charge of the construction, engineering and purchasing details occasioned by the company's multimillion dollar expansion program, as well as the similar program involved in the construction of the many government-owned plants built and operated by the Aluminum Co. Mr. Jolly is a past president of the National Association of Purchasing Agents and is regarded as an authority on plant engineering, construction and purchasing.

♦

DR. HAROLD K. WORK, manager of research and development of Jones & Laughlin Steel Corp., Pittsburgh, has been elected president of the American Society for Metals at its convention held recently in Philadelphia.

♦

J. P. DONALD GARGES recently resigned as chief engineer of the Fairchild Personal Planes division of Fairchild Engine & Airplane Corp. to become chief engineer of East Coast Aeronautics Inc., New York. Mr. Garges was previously chief engineer of the Eastern Aircraft division of General Motors Corp. and had also been associated with the Grumman Aircraft Corp. He is a licensed professional engineer and an associate fellow of the Institute of Aeronautical Sciences.

♦

ROBERT F. KRUPP has been appointed engineering research manager for Gerber Products Co. in Oakland, Calif. He previously had been project engineer with Columbia Steel Co., Pittsburg, Calif.

♦

EMIL THIERFELDER was recently promoted to research and development engineer of Remington Rand Inc. He has been with the company since 1933, when he was employed as a draftsman. After serving as draftsman and designer until 1942 he was given the position of superintendent of accounting machine assembly and served in that capacity until his recent promotion.

♦

ROSS L. FRYER JR. has joined the Diesel Engine Div., American Locomotive Co., Schenectady, N. Y. as assistant mechanical engineer. Mr. Fryer formerly was engine design and design analysis engineer with the White Motor Co., Cleveland.

♦

RAY W. QUALLEY has accepted the appointment as chief products design engineer of the Meyer Furnace Co., Peoria, Ill. Mr. Qualley will have charge of the development of new automatic heating equipment for the Meyer and Weir lines. He was formerly heating laboratory supervisor for Airtemp division of Chrysler Corp., Dayton, Ohio, where he was in charge of development and test of all heating equipment for three years. Prior to this he was associated with the Minneapolis-Honeywell Regulator Co. for 11 years. He attended the college of engineering of the University of Minnesota.

♦

MARTIN C. BUTTERS consulting engineer formerly connected with E. I. duPont de Nemours & Co., has joined the staff of the O. K. Tool Co. Inc., Shelton, Conn., manufacturers of inserted blade milling cutters and single point metal cutting tools.

♦

HOWARD S. BEAN has been named chief of the capacity density and fluid meter section, National Bureau of Standards. This is a newly organized section, being a consolidation of the gas measuring instrument and the capacity and density sections.

♦

H. E. BALSIGER has been appointed director of engineering for Landis Tool Co., Waynesboro, Pa., manufacturers of precision cylindrical grinding machines. He has been with the company since 1925. Succeeding him as chief engineer will be R. E. PRICE, formerly assistant chief engineer.

♦

RONALD A. JOHNSON has been appointed assistant to PAUL BRAINARD, head of the engineering standards department at the Portland, Oregon plant of Hyster Co.

♦

DR. HAROLD GOLDBERG, recently appointed chief of the ordnance research section of the National Bureau of Standards, will be assisted by DR. DONALD BURCHAM, who will act as alternate chief of the section, a unit of the newly organized electronics division.

♦

HANS A. BOHUSLAV was recently appointed as special engineering consultant to the president of R. G. LeTourneau Inc., Peoria, Ill. Mr. Bohuslav is recognized as an authority on high-power diesel and gas engines.

♦

LOUIS E. BARNES has joined North American Aviation Inc., Los Angeles, as engineering designer.

♦

FREDERICK C. REED, previously associated with Link Aviation Corp., Binghamton, N. Y., is now design engineer with Curtiss-Wright Corp., Columbus, O.

♦

PIO FRANCO MARTINUZZI, well known continental engineering designer, was recently appointed a professor of mechanical engineering at Cornell University.

♦

DR. ERNEST F. FIOCK, a leading authority in the field of combustion, has accepted the appointment as chief of the newly organized combustion section of the National Bureau of Standards.

Design Ideas to Cut Costs of Wheels, Gear Blanks, Pulleys

THE examples shown are typical of the different ways in which wheels, gear blanks and pulleys are being built with arc welding. These basic designs can be modified to suit your production needs, depending upon the quantity to be made and the kind of fabricating equipment available.

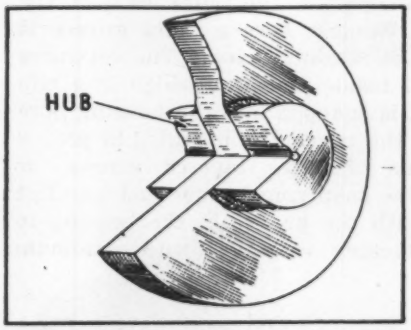


Fig. 1. *Simple gear blank* is made by fillet welding the hub to the web. Parts are flame cut from steel plate.

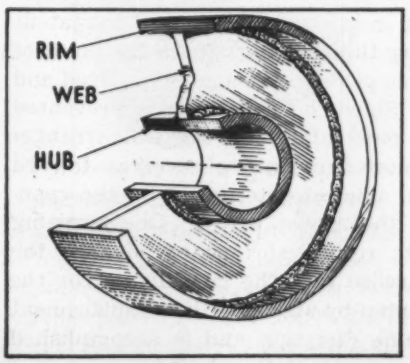


Fig. 2. *Alternate design.* Hub is machined from tubing and rim is rolled from steel strip. Hub and rim are fillet welded to web.

Fig. 6. *Handwheel.* Rim is formed from round bar stock or tubing. Spokes are plain round stock. Steel handwheels will not fracture from impact. →

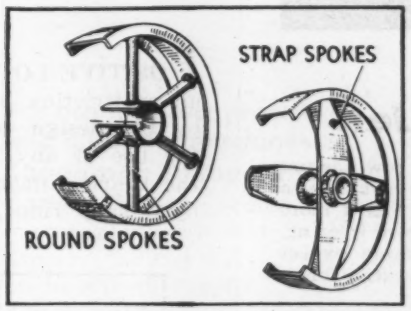


Fig. 3. *Low cost wheel* is made with spokes formed from round bars or steel straps. Spokes are fillet welded inside the channel rim. Hub if required is produced from steel tubing.

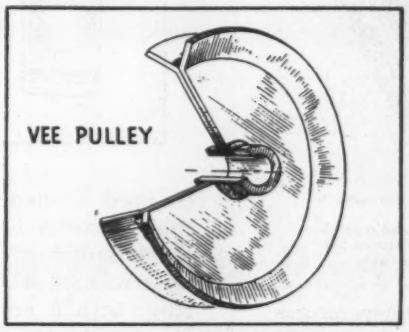


Fig. 4. *Pulley* is fabricated from two steel discs formed to produce a vee-shaped rim.

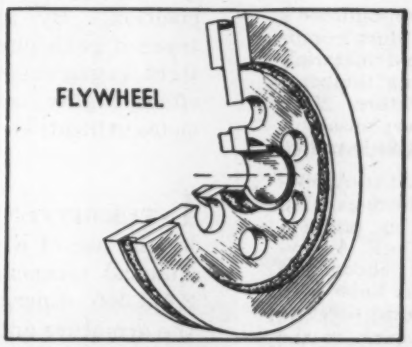
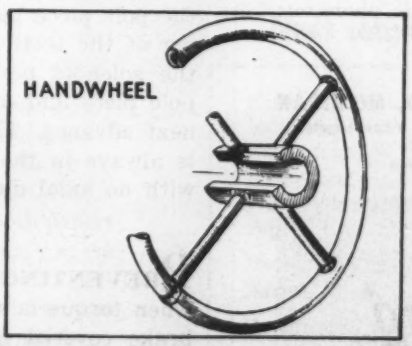
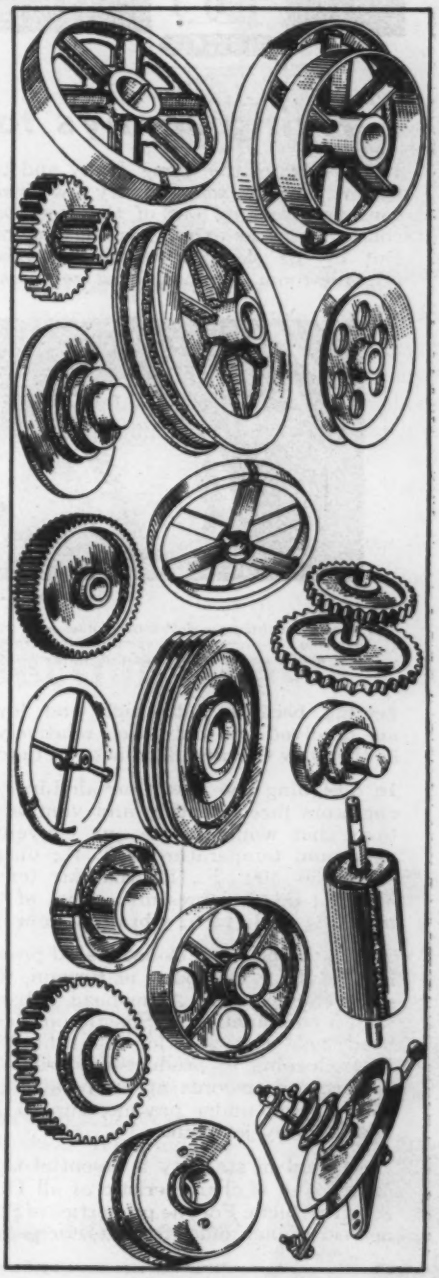


Fig. 5. *Flywheel* is made by welding two steel rims to web by a single groove weld. With welded design, metal is concentrated where it is needed most . . . at the rim.





Detailed information on the design of all types of machine parts is contained in the "Procedure Handbook of Arc Welding Design and Practice." Price $1.50 postpaid in the U.S.A.; elsewhere $2.00.

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Silicone News

DC SILICONES

Flying Jennys to Jets

In the days of the flying Jenny and the cow pasture airport, comfort was a luxury few airmen had time to consider. Keeping out of the tree tops was a more constant problem than keeping fingers from freezing. But in the sleek new airliners, passengers expect drawing-room comfort. That requires creative engineering because both high and low temperatures are involved and only such relatively new materials as the Dow Corning Silicones can take both extremes.

PHOTO COURTESY ARROWHEAD RUBBER CO.

Silastic-coated glass cloth heating duct seals withstand continuous long time exposure to operating temperatures between 350° and 400° F. in new Consolidated Vultee Convair-Liners.*

In designing the new Convair-Liner, Consolidated's engineers faced heating and ventilating duct conditions that would frizzle any conventional material; maximum temperature 450° F.; operating temperature, 350°-400° F.; internal air temperature, 250°-350° F.; internal pressure, 10 in. of water; misalignment, ⅛ to ¼ inch; vibration from mild to extreme.

That's the problem Consolidated presented to Arrowhead Rubber Company of Vernon, California. In 10 days engineers at Arrowhead solved this problem with a combination of Silastic on glass cloth. Arrowhead also uses Silastic, the rubber-like silicone by Dow Corning to produce duct seals that have high performance records at temperatures from −89° to 450° F. and under pressures up to 150 p.s.i. in the newest army jet planes.

That kind of stability is essential to the aircraft industry and is characteristic of all Dow Corning Silicone Products. For the properties of Silastic, phone our nearest branch office or write for pamphlet No. F5-B.

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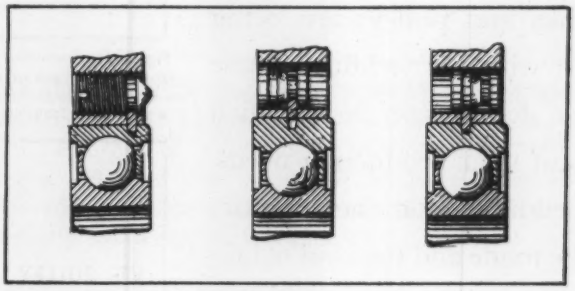
NOTEWORTHY PATENTS

POSITIVE LOCKING against axial displacement of an antifriction bearing outer race is made possible by the design covered in patent 2,443,501 without the use of any space other than that required for the bearing itself. No offsets, shoulders, cap members, snap rings, or other type axial retainer need



be used beyond the end of the bearing. A wedge-shape groove is employed in the outer race of the bearing and in the housing bore a plain groove is used to hold a special retaining ring. The retaining ring, with a normal inside diameter which is a slip fit over the bearing, is snapped into the housing bore groove, after which the bearing is installed in proper position. By means of three tapered screws, or tapered push pins, the snap ring is squeezed into full tight engagement with the groove in the bearing to effect highly satisfactory retention with minimum space utilization.

INTERMITTENT ROTATION of an electric motor by the use of a solenoid coil, an armature and a mechanical escapement mechanism is covered in patent 2,444,566. Energizing the solenoid causes the poles of the armature and pole piece to become magnetized and attract each other. Since the pole piece is prevented from moving by a pawl and rachet wheel arrangement, the shaft-mounted armature revolves toward the pole piece by an amount determined by the spacing of the teeth on the rachet wheel. De-energizing the solenoid permits return springs to advance the pole piece and otherwise arm the mechanism for the next advance. The step-by-step angular displacement is always in the same direction and is accomplished with no axial displacement of the shaft.

PREVENTING REVERSE ROTATION of a shaft when torque is applied to the driven end, the reverse brake covered in patent 2,444,592 allows free rotation when the torque acts on the driving end. A brake member floating within a stationary sleeve couples the ends of the driving and driven shafts

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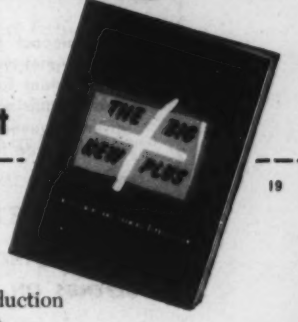

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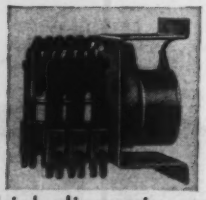

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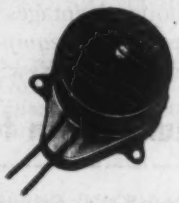

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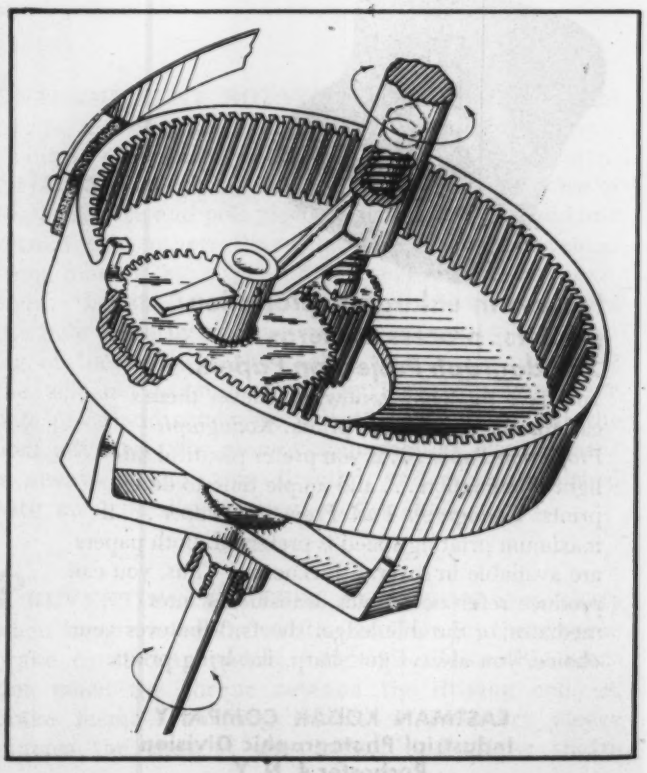
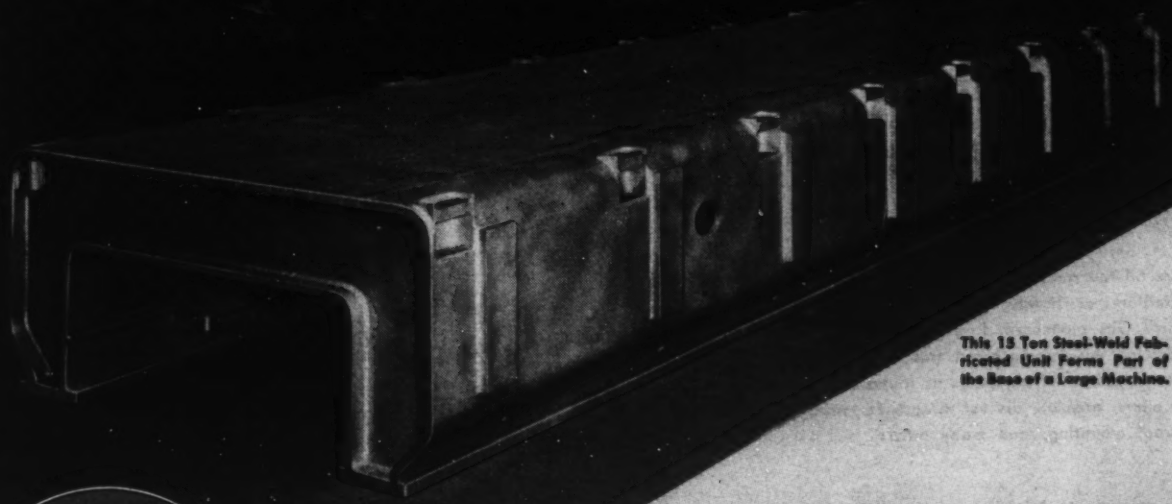
with a lost-motion connection. Rotation of the driving shaft forces the brake member away from the stationary sleeve permitting normal direct drive, but rotation of the driven shaft causes the brake member to become wedged in the stationary sleeve preventing reversal of both shafts. The patent has been assigned to Ross Gear & Tool Co. by William K. Creson.

AUTOMATIC CLUTCH for automotive and similar use consists of flywheel-mounted, spring-restrained, centrifugal fly-weights that force a conventional pressure plate type clutch into engagement when the engine reaches a predetermined point above idling speed. Pressure for holding the clutch in engagement is supplied by coiled compression springs through a lever mechanism. The clutch can also be operated by the usual clutch pedal and throw-out collar arrangement. The patent, no. 2,444,964, has been assigned to Dana Corp. by W. Vincent Thelander.

REMOTE CONTROL of radio tuning devices is achieved through the planetary mechanism covered in patent 2,444,448. Assigned to the Bell Telephone Laboratories by Walter F. Kannenberg, the device automatically changes the speed ratio between the motor shaft and the tuning mechanism from high speed to low speed, or vice versa, in order to locate the region of critical tuning and then accurately locate the critical tuning point. When in slow speed operation, the sun gear drives the planetary gear around the ring gear which is held by a friction brake. A threaded coupling between the drive shaft and the driven planet carrier displaces the planetary gear



Steel-Weld FABRICATION



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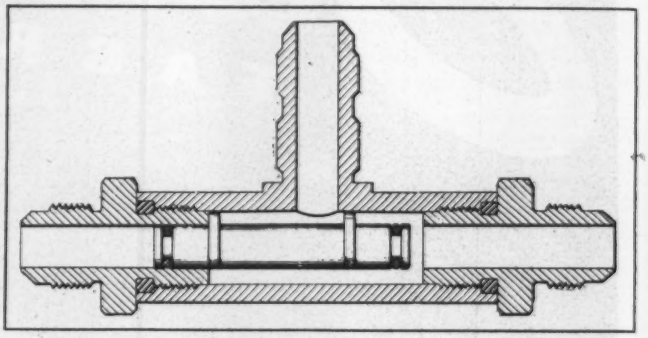
axially, which, after a predetermined number of slow-speed rotations, contacts a stop on the ring gear. The driven shaft then rotates at the same speed as the motor against the frictional effect of the brake.

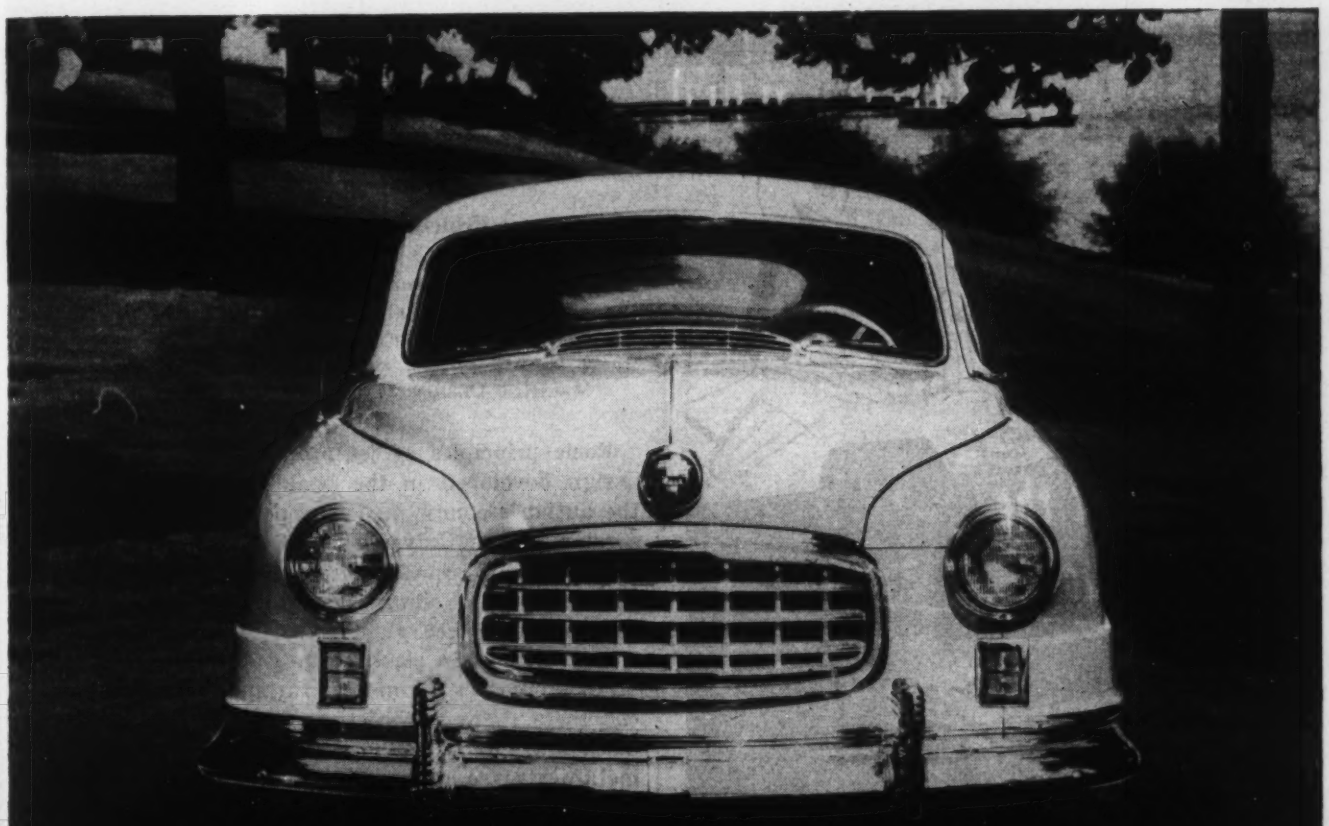
RESPONDING AUTOMATICALLY to differential pressures, hydraulic shuttle valve covered in patent 2,445,505 will connect a hydraulic system to a gas



pressure source in the event of failure of the hydraulic pump. Rubber O-rings used on the valve plunger eliminate precision fitting of the valve in the valve body. Benjamin N. Ashton has assigned the patent to Electrol Inc.

UNIQUE COMBINATION of hydraulic pump and accumulator unit, invented by Benjamin N. Ashton, eliminates the conduits normally used between such units. Assigned to Electrol Inc., patent 2,444,550 covers the use of a wobble-plate hydraulic pump within a metallic bellows accumulator. The pump delivers oil both to the conduits of the hydraulic system and to the accumulator until pressure in the system has reached a predetermined point at which a spring and ball type unloader disengages the wobble plate from the drive shaft. Compressed air for loading of the accumulator is admitted between the bellows and the outer casing of the unit. An integral spring-loaded relief valve is also provided as part of the system.

BALANCED FORCE is maintained on the barrel of the swash-plate pump covered in patent 2,445,281 by the use of two swash or wobble plates and two concentric rows of plungers. Inner and outer plunger rows are actuated 180 degrees out of phase by the two swash plates so that a plunger on the discharge stroke is diametrically opposed by a plunger in the other row also on the discharge stroke. Similarly, a plunger on the suction stroke is diametrically opposed by another plunger on the suction stroke, thereby approximately balancing the forces tending to move the barrel away from the valve seats. Swash plate thrust rings are roller bearing mounted. The patent has been granted to Charles H. Rystrom.



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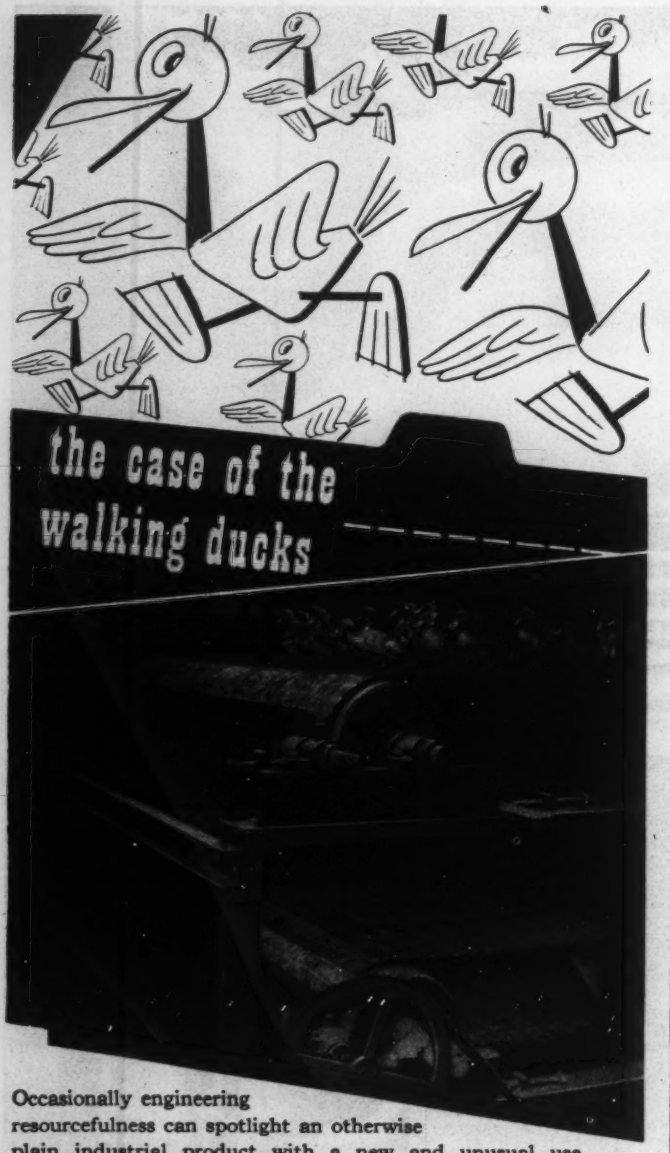

Occasionally engineering
resourcefulness can spotlight an otherwise
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Newly hatched ducklings, it seems, have to be kept moving to be kept alive. Placed on this specially built woven wire belt moving at a slow rate of speed, the ducklings remain there for eight days . . . continually treadmilling away from the falling end of the belt. Mortality rate dropped to zero. By-product recovery . . . duck droppings for fertilizer . . . is aided by the open mesh of the woven wire belt.

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Assets to a Bookcase

Principles of Jet Propulsion

By M. J. Zucrow, professor of gas turbines and jet propulsion, Purdue University; published by John Wiley & Sons Inc., New York; 563 *pages,* 6 *by* 9¼ *inches, clothbound; available through* MACHINE DESIGN, $6.50 *postpaid.*

Basic principles of jet propulsion and gas turbine design developed in the book are an outgrowth of the author's course on jet propulsion under the sponsorship of the University of California. It contains the necessary fundamental theory pertinent to a general understanding of jet propulsion engines and gas turbine power plants. Major topics covered include continuous combustion gas turbines, types of air compressors, axial-flow turbines, and combustion chambers. The turbojet engine and the rocket are discussed. Recent advancements in high-temperature metallurgy are summarized in the final chapter.

□ □ □

How to Keep Invention Records

By Harry A. Toulmin, Jr.; published by Research Press Inc., Dayton, Ohio; 78 *pages,* 5½ *by* 8 *inches, clothbound; available through* MACHINE DESIGN, $2.50 *postpaid.*

Necessity of a written explanation in presenting to inventors and corporations owning inventions the grave need of adequate records makes this a valuable reference book. It is pointed out that expensive litigation can often be avoided if proof is kept of the essential steps and their dates in connection with inventions. The general nature of industrial property and monopolies granted to protect it are discussed in the first part of the book. A practical method of insuring the recording of dates is next presented, and a final chapter deals with the methods of patent investigation. Specific points covered include: Date of conception, date of disclosure to others, reduction to practice by test and experiment, and proof of ordering materials for the first production run.

□ □ □

International Industry Yearbook

Edited by Lloyd J. Hughlett; published by the Kristen-Browne Publishing Co., New York; 414 *pages,* 8½ *by* 11 *inches, clothbound; available through* MACHINE DESIGN, $10.00 *postpaid.*

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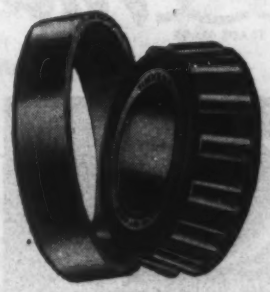

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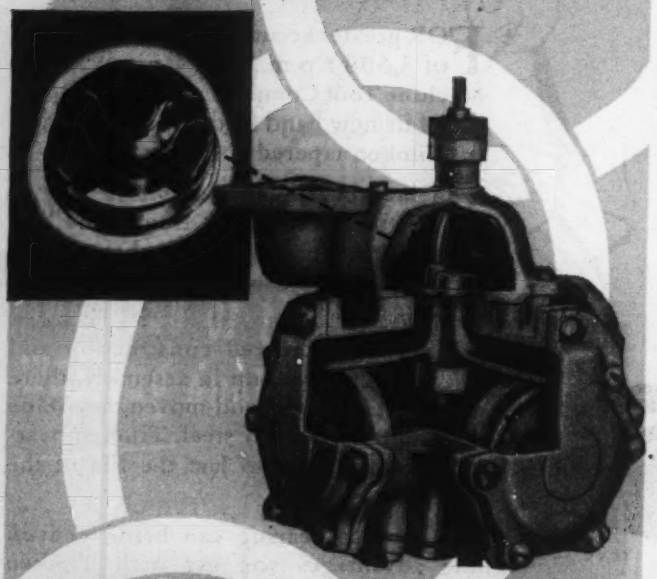
PROBLEM:

To supply a rotary valve for gasoline meters that would slash normally high maintenance costs and eliminate inaccuracy in meter measurements.



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profession. It provides in a single volume an overall picture of the advances made by the industry as a whole and is especially intended for those who are unable to follow the large number of technical publications directed to their particular field. Among the topics covered are: Air conditioning, refrigeration and heating, compressed air, electronics, industrial design, and plastics. Each of the 27 sections of the book has been prepared by an expert in the field covered. Extensive references give sources of additional information on any specific subject.

□ □ □

Rotary-Valve Engines

By Marcus C. Inman Hunter, consulting and research engineer; published by John Wiley & Sons Inc., New York; 214 pages, 5½ by 8½ inches, clothbound; available through MACHINE DESIGN, *$5.00 postpaid.*

Beginning with the history of the rotary valve, the author illustrates the application of rotary and semirotary valve systems to both old and modern engines. The advantages of quiet operation, freedom from vibration and elimination of inertia troubles are discussed as well as some of the reasons for the present limited use of the rotary-valve principle. Chief disadvantage of the system has been, of course, the proper lubrication of the relatively high-friction rotating valve. Mr. Hunter believes that rotary valves will soon show superiority to and threaten the supremacy of conventional reciprocating systems such as poppet valves in automobiles and slide valves in steam engines. The book, originally published in England, is a well illustrated, practical reference for the designer of internal-combustion engines.

□ □ □

Mechanics of Materials

By Dr. Glen Murphy, professor of theoretical and applied mechanics, Iowa State College; published by Irwin-Farnham Publishing Co., Chicago; 304 pages, 6 by 9¼ inches, clothbound; available through MACHINE DESIGN, *$4.50 postpaid.*

This textbook was written to assist in developing an understanding of the behavior of loaded structural members and machine parts. The author directs the reader's attention to those principles which have been found useful in explaining observed phenomena, and points out standard procedures of analysis in order that the reader may readily understand the bulk of engineering literature on the subject. Principles of statics, geometrical characteristics of the loaded member and effects of the material's properties have been emphasized in considering each type of stress situation. A minimum of emphasis is placed on formulas as such. At appropriate intervals some elementary aspects of design application have been

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Check these Snap-Lock superior design and construction features. They will bring you dependable, trouble-free limit switch performance:

- ✓ **SNAP make and break**
- ✓ **Pure silver self-wiping contacts**
- ✓ **Positive locking, either on or off—can't stop on dead center**
- ✓ **Separate sealed electrical and mechanical sides**
- ✓ **Hardened steel moving parts; forged levers**

But Snap-Lock superiority doesn't stop there; Snap-Lock engineering service is an important part of the finished package. We gladly analyze a customer's needs, recommending the exact unit to save space, eliminate expensive mechanical contrivances and insure trouble-free switch performance.

That service costs you no more—but it will save you time—and money. Let us function as your switch design department.

Ask us for your copy of this new illustrated factual 12-page folder on standard Snap-Lock Limit Switches. Request bulletin EM-47.

Regular Style

Push Lever Style

Explosion & Water Resisting

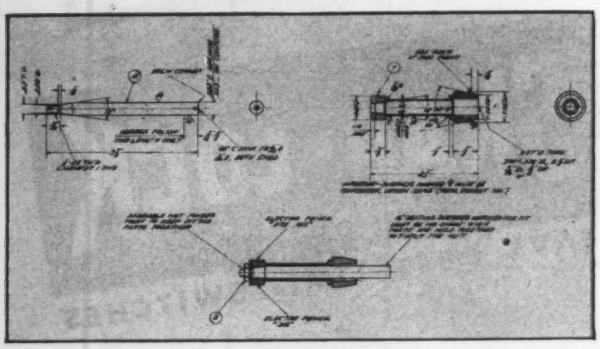
Neutral Position and Short Travel Styles also available

The NATIONAL ACME CO.

170 EAST 131st STREET • CLEVELAND 8, OHIO

Acme-Gridley Bar and Chucking Automatics: 1-4-6 and 8 Spindle • Hydraulic Thread Rolling Machines • Automatic Threading Dies and Taps • The Chronolog • Limit, Motor Starter and Control Station Switches • Solenoids Centrifuges • Contract Manufacturing

with STEEL – the small extra first cost of test samples pays off in assurance of efficiency and durability of the finished product.



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The small extra first cost of Arkwright Tracing Cloth, over that of tracing paper, repays many times over in the efficiency and durability of valuable drawings.

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Foresighted drafting departments regularly specify fine-woven, expertly bonded Arkwright, rather than perishable tracing paper, for *every drawing worth keeping for possible future use.*

Read the *Big Six Reasons* why Arkwright Tracing Cloth eases work, improves jobs, resists wear and time. Then send for generous samples and prove this superiority on your drawing board. Sold by leading drawing material dealers everywhere. Arkwright Finishing Company, Providence, R. I.

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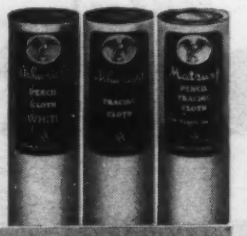

ARKWRIGHT

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AMERICA'S STANDARD FOR OVER 25 YEARS

included in order to tie in the theoretical analysis with practical engineering problems. Sample problems have been included after each chapter.

□ □ □

Direct-Current Machinery

By R. G. Kloeffler, R. M. Kerchner and J. L. Brenneman, electrical engineering department of Kansas State College; published by Macmillan Co., New York; 388 *pages,* 6 *by* 9½ *inches, clothbound; available through* MACHINE DESIGN, $5.75 *postpaid.*

Containing the latest information available on new theories, developments and applications in the direct-current field, this is the revised second edition of the text originally written in 1934. Although generation, transmission and distribution of electric power will continue via the alternating-current system, the authors believe that direct-current machinery will continue to occupy a prominent place in the power field because of its superior torque and speed characteristics in applications where accurate control is desirable. Included in the revised edition are discussions of the amplidyne, multifield exciters, welding generators, and aircraft generators. The newer theories of communications, methods of starting and automatic control are also covered. All circuit diagrams conform to the graphical standards approved by the American Standards Association.

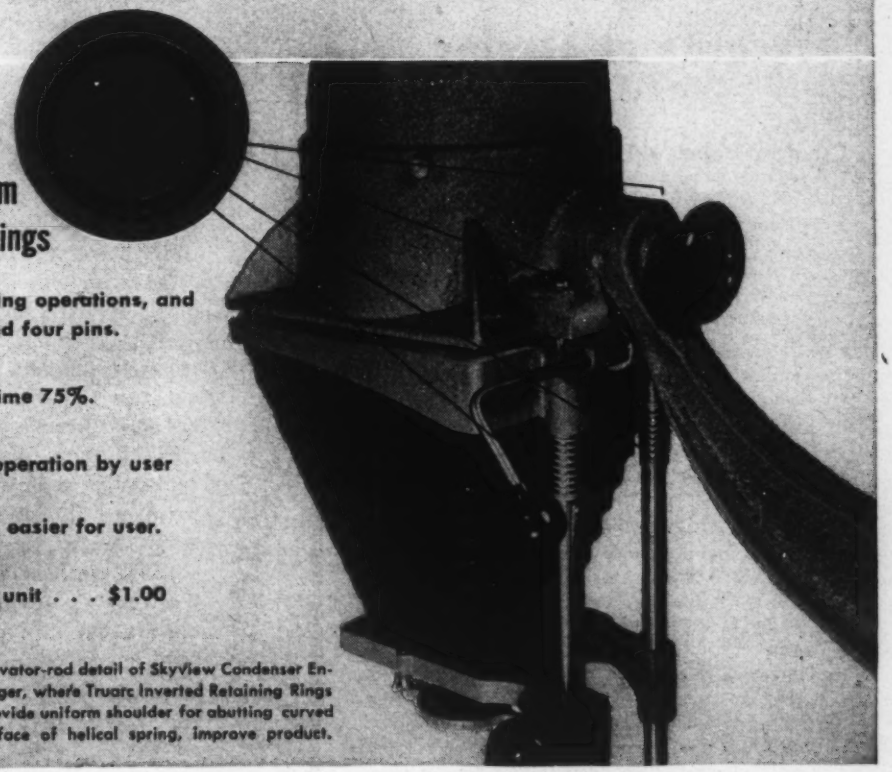
"Practical Considerations in Die Casting Design", a 237 page book published by the New Jersey Zinc Co., is a well-illustrated presentation of actual design practice in die casting. Among the specific design factors covered are: Section thickness, coring, fillets and edges, die-cast threads, inserts, undercuts, flash removal, piercing and forming, and appearance. The 6 by 9 inch clothbound book may be obtained from the company at 160 Front St., New York 7, for $3.00.

Just released by the Department of Commerce, a report titled, "Investigation on the Welding of High - Strength Aluminum Alloys" describes three approaches to the problem of improvement of welded aluminum joints. Since the ductility of a conventional weld is only from 5 to 30 per cent of that of the parent plates, the use of a more ductile filler rod was investigated and found to result in a superior weld. Also, tensile efficiencies of welded joints were found to be improved by heat treatment. The last theory investigated, the use of unusual joining methods such as cold pressure welding has not as yet shown any definite promise. The 63-page booklet, PB 92831, is available in photostat form for $8.75 and in microfilm form for $3.00 from the Library of Congress, Photoduplication Service, Publication Board Project, Washington 25, D. C.

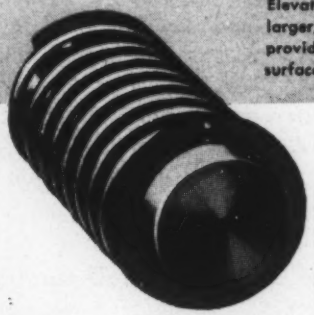
Truarc inverted rings align shafts, save 20 minutes . . . . $1.00 per unit

Production savings and sales advantages result from redesign with four Truarc rings

- Eliminate two drilling, two tapping operations, and the fabrication of two collars and four pins.
- Eliminate two set screws.
- Cut dis-assembly, re-assembly time 75%.
- Make for closer tolerances.
- Make drive shaft self-aligning: operation by user greatly simplified.
- Make more delicate adjustments easier for user.
- Streamline entire unit.
- TOTAL OVERALL SAVINGS, per unit . . . $1.00



Elevator-rod detail of Skyview Condenser Enlarger, where Truarc Inverted Retaining Rings provide uniform shoulder for abutting curved surface of helical spring, improve product.



Like the Skyview Camera Company of Olmsted Falls, Ohio, re-design with Truarc and you will cut costs and improve your product too. Wherever you use machined collars, nuts, bolts, snap rings, cotter pins —there's a Truarc ring that does a better job of holding parts together. All Waldes Truarc retaining rings are precision engineered, easy to assemble and dis-assemble, retain circularity always to give you a never-failing grip. They can be used over and over again. Send us your problem. Waldes Truarc engineers will be glad to show how Truarc can help you.

WALDES

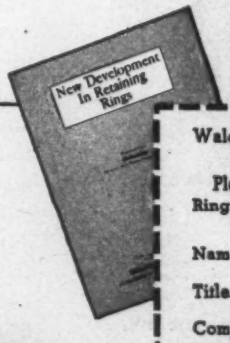
TRUARC

REG. U. S. PAT. OFF.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS ARE PROTECTED BY U. S. PATS. 2,302,948; 2,026,454; 2,416,852 AND OTHER PATS. PEND.



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Please send booklet, "New Development In Retaining Rings" to:

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HERE'S NEWS!

If you want

IMMEDIATE

records of strains . . .

Here's a strain measuring device that produces records immediately for interpretation. The "STRAIN ANALYZER" consists of a Model BL-310 Strain Amplifier and the Brush Direct-Inking Oscillograph. It's completely self-contained, requiring only two external strain gage connections, one dummy gage and one active gage cemented to the piece being tested.

The equipment records either static or dynamic strains up to 100 cps. Direction as well as magnitude of the measured strains can be read from the record. The "STRAIN ANALYZER" is readily calibrated for individual gages so that the strain can be read from the chart directly in microinches per inch.

When used with Baldwin Southwark SR-4 Gages of 120 ohm resistance, the maximum sensitivity of the unit is 10 microinches per inch strain per chart division pen deflection. An attenuator switch changes the sensitivity in the following steps: 10, 20, 50, 100, 200, 500, 1000 and 2000 microinches per inch per division. While specifically designed for the 120 ohm gage, the equipment can be used for higher resistance gages. It is also applicable for use with many resistance sensitive pickups and can be used to record pressures, temperatures, accelerations, forces, etc., provided the equipment is calibrated in the terms of the particular pickup used.

Investigate the "STRAIN ANALYZER"

The new Model BL-310 Strain Measuring Equipment with Brush Direct Inking Oscillograph.

Write today for detailed specifications . . .

THE Brush DEVELOPMENT CO.

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MAGNETIC RECORDING DIV. • ACOUSTIC PROD. DIV.
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Process Control Valves

(*Continued from Page* 132)

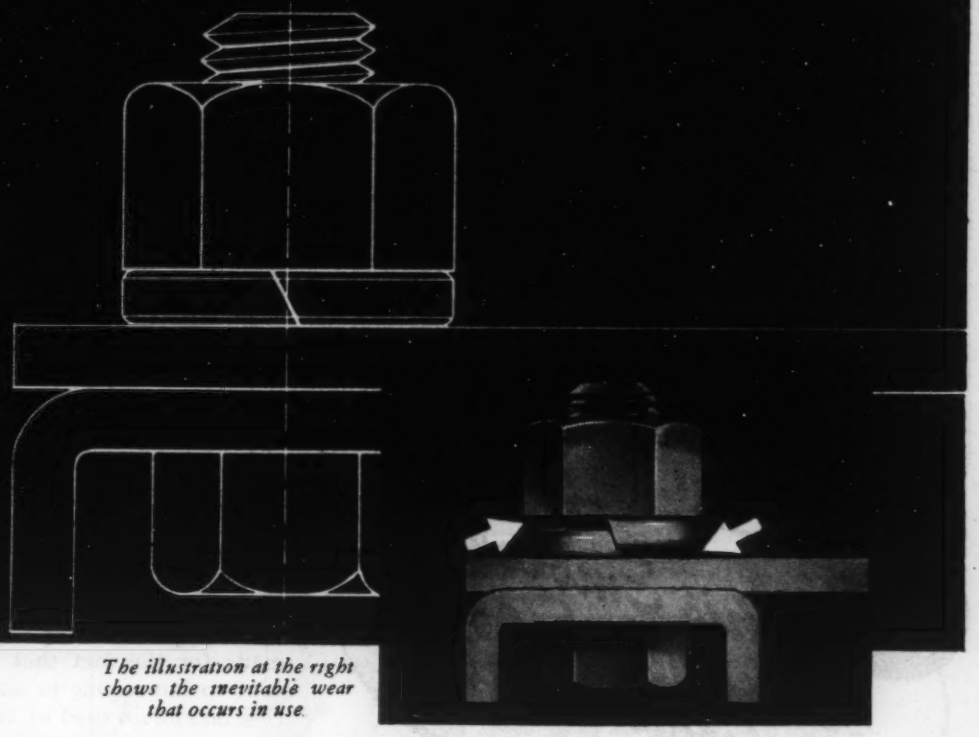
notched types and consequently seems to resist localized erosion of the seats and disks which appears in the latter type due to flow-stream concentration effected by the notches. The ratio-plug valve, the only equal-percentage type which maintains those characteristics between fairly wide limits, has a distinct weakness in the close clearances and low closing angle and should only be used to regulate flow of controlled mediums which do not deposit scale or carry suspended solids. A slight scale deposit or solid particles caught between the seat and plug can jam the valve as it closes. Even the V-notch and modified ratio (parabolic) plug valves should be used with caution if solids are present in the controlled medium.

Another advantage of beveled-disk valves over other types is that less lift is required than on ported and plug types of the same size. This often allows the use of smaller diaphragm motors and this, coupled with the smaller stroke, results in a valve which can be moved from one opening to another more rapidly with a given instrument relay valve capacity. This reduction in valve lag can materially improve those processes in which valve lag plays an important part such as many level-control, pressure-control and flow-control applications and on simple "mixing type" temperature control circuits. The use of smaller diaphragm motors and shorter lifts can be a disadvantage if equal valve friction is present as it can cause greater frictional dead spots to be present in the control circuit than if longer lifts and more powerful motors were used. However, on any control application difficult enough and important enough to warrant consideration of valve characteristics, a valve positioner should be used for elimination of the frictional effect.

Curves Deviate from Theoretical

Actual experimental curves of flow versus lift on equal-percentage valves show considerable deviation from the theoretical characteristic. This is not surprising in view of the extremely small machining tolerances that are required to hold the equal-percentage characteristics down to small values of flow. The smaller the valve, the more difficult it becomes to maintain the desired curve at small openings. On large valves, six inches and over, it is conceivable that fair adherence to the equal-percentage curve could be obtained down to perhaps 5 per cent of maximum flow; 15 per cent would be a realistic figure on valves one inch in size and smaller. Below these values the clearance between plug and seat ring is too small for good mechanical operation of the valve so the plug is relieved to maintain a reasonable minimum clearance down to the point at which tight closure is achieved by the beveled portion of the plug meeting the seat. This makes the valve operable mechanically, but it leaves a discontinuity in the valve characteristic curve as shown in *Fig.* 9, which gives typ-

To Draftsmen, Engineers and Designers



The illustration at the right shows the inevitable wear that occurs in use.

Fundamentals are important, this is fundamental.

Many devices can lock a nut on a bolt so the nut **cannot** turn. But that alone is not sufficient.

Many constructions – so bolted – will loosen because of bolt stretch, and the frictional wear of metal on metal, burrs, flares, and the pulverizing of paint, scale and rust.

Since the advent of the castellated nut, research has found that looseness is usually caused by ductility, and wear at every contact point of metal surfaces.

From an engineering point of view, nut **locking** devices – although they may keep the nut from turning – do not and cannot give the necessary spring reaction that keeps bolted assemblies tight. **Vibration** and **stress loosen everything** – they always have and always will.

You **must** use a spring which expands as wear occurs. Expanding **spring** power retards initial wear, then compensates for later wear, and **holds parts tight** for a **long period** of time. **A strong spring does it – nothing else can.**

So **with** or **without** a nut locking device specify spring washers on every bolted construction you design.

The **live spring** gives you safety, economy, and efficiency.

Kantlink spring washers are strong, non-tangling, helical springs with wide and ample reactive power – (spring expansion).

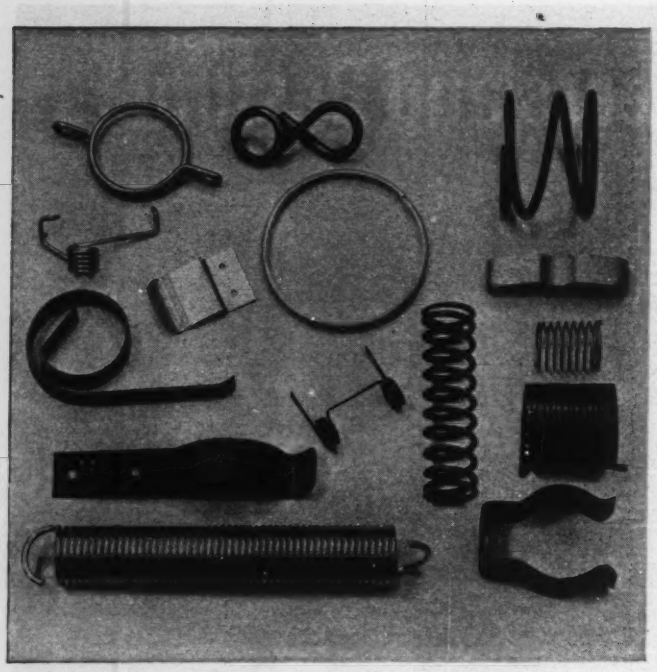
There is no substitute as economical. No fixed nut nor any other type or design of washer can possibly equal the great holding power of a **long range live spring** – a big helical spring such as Kantlink.

Write today for a descriptive folder.

Originators of KA[illegible] the [illegible] range spring washer

THE NATIONAL LOCK WASHER COMPANY

Newark 5, New Jersey — Milwaukee 2, Wisconsin



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This Emblem is the Mark of a Good Spring

During the many years we have been making springs, this trade mark has come to stand for dependable, even *exceptional* service. Reliable spring users know that we can be relied on for the creative ability in design, and the craftsmanship in processing, which eliminate costly, troublesome delays and difficulties. Many an engineering department, many a purchasing agent, have learned that they can by-pass chronic spring headaches, and secure the right spring at the right price by making Reliable their sole source of supply. We have gone to great lengths, in perfecting our own organization, to deserve this kind of confidence.

On wire forms and small spring stampings as well, we offer you a type of cooperation and quality which has made many of America's finest manufacturers long-time customers of ours. Remember, too, that when we make a delivery promise, we definitely mean it.

Additional 4-slide and other equipment now give us greater capacity than ever. Send us your specifications. Ask for Catalog, also Bulletin "Common Sense of Spring Design."

The Reliable Spring & Wire Forms Co.

3167 Fulton Rd. Cleveland 9, Ohio

Representatives in Principal Cities

YOU CAN RELY ON

Reliable Springs

ROUND AND FLAT WIRE SPRINGS — COILS — HOOKS — BENDS — LIGHT STAMPINGS

ical flow-lift curves for average-sized valves of the various types. In the region of this clearance flow, very little change in flow occurs in that portion of the valve lift where neither the shaped plug nor the beveled portion of the plug is changing the free area.

This discontinuity is characteristic of all shaped plug valves and is also found in the V-notched type. The lack of continuity at the clearance flow region is a serious weakness of these valves if they are ever called upon to control near that opening because a dead spot is introduced into the control circuit. A fair amount of lift is inoperative in changing flows so it has the effect of valve friction and causes "wandering" control whenever the process load calls for controlled medium flows of that quantity. Above and below this flow, the curves are continuous, making a positive change in flow for every valve movement. It should be noted that unlike valve friction, this discontinuity cannot be eliminated by a valve positioner.

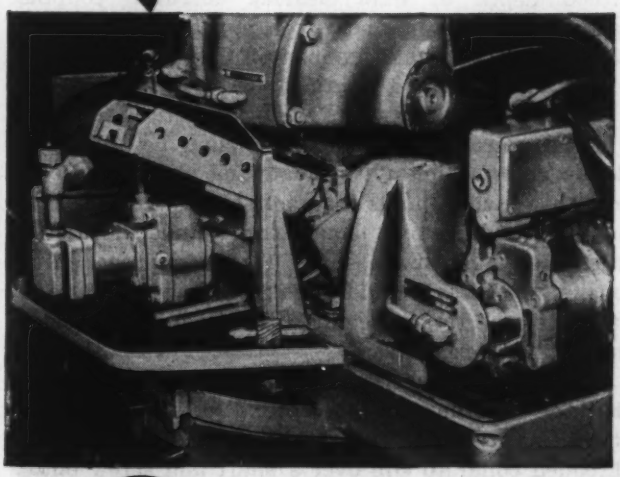
The clearance flow discontinuity puts a severe sizing limitation on equal-percentage valves because they should only be called upon to control at higher flows. In applying these valves to processes having a wide range of loads it is necessary to size them carefully to insure that they always operate at openings above the discontinuity. By reference to *Fig.* 9 it can be seen that at best these valves are only good over a twelve-to-one change in load. If some allowance is made for the fact that it is bad practice as well as next to impossible to size a valve so that it just carries maximum load at full opening, a reasonable usefulness of these valves might be taken as an eight-to-one range of load. Possibly, fifteen-to-one on large valves but nearer five-to-one on small valves. The beveled disk obviously has no discontinuity in its flow-lift curve.

Aluminum Cold Welded

RESEARCH laboratories of the General Electric Company in London have developed a new process for the easy and effective cold welding of aluminum, certain aluminum alloys and other metals, after surface treatment. The process involves application of high pressure to the work pieces to be joined by specially designed dies. The pressure not only brings the two surfaces into close contact but melts them so that the two pieces of metal become welded together.

It is of the utmost importance that the oxide film which is characteristic of aluminum and its alloys be removed, and that the clean surface thus developed not be contaminated or handled. Chemical methods of cleaning are unsuitable, it being found that consistently good welds are obtained after using a power-driven rotary scratch brush. Steel-wire brushes having a surface speed of about 3000 feet per minute have been found to be most satisfactory. The new process promises to be of much value also in electrical engineering, inasmuch as recently a joint between aluminum and copper strip was successfully made at room temperature.

automatic loading *Triples Production* of shaved gears



The installation of Red Ring Gear Shaving Machines equipped with automatic loaders at the Warner Gear Division of Borg-Warner Corporation has practically tripled production of twelve tooth pinions.

These pinions have a 1" face, 13.5 D.P., 20° P.A. and are DIAGONALLY shaved to the Elliptoid tooth form. Tolerance on the involute is held to .0002". An arbor is pressed into each pinion before going into the loader magazine.

The operator merely feeds the pinions into the loader magazine and removes them when ejected from the machine completely shaved. Both loading and shaving are entirely automatic while the machines run continuously.

Red Ring Universal Diagonal Machines shave gears from 1" to 12" pitch diameter by either the conventional or diagonal methods.

If you are producing precision gears in quantity, ask for descriptive literature on Red Ring Shaving Machines.

5161

SPUR AND HELICAL GEAR SPECIALISTS
ORIGINATORS OF ROTARY SHAVING AND ELLIPTOID TOOTH FORM

NATIONAL BROACH AND MACHINE CO.

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WORLD'S LARGEST PRODUCER OF GEAR SHAVING EQUIPMENT

because contacts get a GENEROUS WIPE

Unique spring suspension adds a self-cleaning action to the heavy, silver-to-silver contacts of Ward Leonard's 105 Heavy-Duty Midget Relays. These features make them self-aligning, too.

Use Ward Leonard 105 Midgets on jobs normally requiring heavier relays.

Write for Relay Catalog. Ward Leonard Electric Co., 58 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC COMPANY

Result-Engineered Controls

RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

Screw Thread Standards

(*Continued from Page* 128)

by the crest of the unworn tool and is not specified. It may be determined by adding $0.7939p$ to the maximum pitch diameter of the internal thread.

MINOR DIAMETER TOLERANCES: For external threads the minimum minor diameter is established by the crest of the unworn tool and is not specified. It may be determined by subtracting $0.6495p$ from the minimum pitch diameter of the external thread.

Internal thread tolerances for the minor diameter of all classes and standard series of threads will be the same as those now specified for Classes 2 and 3.

The complete new standard will include tables of the maximum and minimum values of pitch diameter, major diameter, and minor diameter for all classes.

Old and New Threads Interchangeable

It should be emphasized that all classes of the unified threads are mechanically interchangeable with the corresponding national threads.

THREAD SERIES: As mentioned earlier, the series and sizes are virtually the same as in the ASA and SAE standards. *Coarse-thread* series is recommended for general use in engineering work and in machine construction where conditions are favorable to quick and easy assembly of parts with bolts, screws and other threaded components. *Fine thread* series is recommended for general use in automotive and aircraft work.

Extra-fine thread series is intended for special uses where thin-walled material is to be threaded, where thread depth of nuts clearing ferrules, coupling flanges, etc., must be held to a minimum, and where maximum practicable number of threads is required within a given thread length.

The 8-thread series has application for fastenings which require that an initial tension be set up by elastic deformation of the fastening and of the components which it holds together. Examples are bolts for high-pressure pipe flanges and cylinder-head studs which hold against pressure. To secure proper initial tension the pitch should not increase with diameter, otherwise the torque required to assemble the fastening would be excessive.

The 12-thread series is used in machine construction for thin nuts on shafts and sleeves. It is the coarsest thread in general use that will permit a threaded collar to slip over a shaft and screw onto a threaded shoulder, the difference in diameter between shoulder and shaft being $\frac{1}{8}$-inch. The 12-thread series also provides continuation of the fine-thread series in diameters larger than $1\frac{1}{2}$ inches.

The 16-thread series is intended for applications which require a relatively fine thread such as threaded adjusting collars and bearing retaining nuts. It also provides continuation of the extra-fine series in diameters larger than 2 inches.

MEETINGS AND EXPOSITIONS

Jan. 19-21—

Society of Plastics Engineers Inc. Annual meeting to be held at Bellevue-Stratford Hotel, Philadelphia. W. J. Miller, Rohm & Haas Co., Washington Square, Philadelphia 5, Pa., is publicity chairman for the national meeting.

Jan. 24-27—

Institute of the Aeronautical Sciences. Seventeenth annual meeting to be held at Hotel Astor, New York. Robert R. Dexter, 2 East 64th St., New York 21, N. Y., is secretary.

Jan. 24-27—

American Society of Heating and Ventilating Engineers. Fifty-fifth annual meeting and ninth international exposition to be held at the International Amphitheatre, Chicago. A. V. Hutchinson, 51 Madison Ave., New York 10, N. Y., is secretary of the society and Charles F. Roth, Grand Central Palace, New York 17, N. Y., is exposition manager.

Jan. 31-Feb. 4—

American Institute of Electrical Engineers. Winter general meeting to be held at Hotel Pennsylvania, New York. H. H. Henline, 33 West 39th St., New York 18, N. Y., is secretary.

Feb. 13-17—

American Institute of Mining and Metallurgical Engineers. Annual meeting of the Iron and Steel and Institute of Metals divisions to be held in San Francisco. Additional information may be obtained from headquarters of the society, 29 West 39th St., New York 18, N. Y. Ernest Kirkendall is secretary of the metals divisions.

Feb. 28-Mar. 4—

American Society for Testing Materials. Spring Meeting and committee week to be held at Edgewater Beach Hotel, Chicago. Robert J. Painter, 1916 Race St., Philadelphia 3, Pa., is assistant to the secretary.

Mar. 8-10—

Society of Automotive Engineers Inc. Passenger car, body, and production meeting to be held at Book-Cadillac Hotel, Detroit. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Mar. 10-12—

American Society of Tool Engineers. Seventeenth annual meeting to be held at William Penn Hotel, Pittsburgh. H. E. Conrad, 10700 Puritan Ave., Detroit 21, Mich., is executive secretary.

Mar. 28-30—

Society of Automotive Engineers Inc. Transportation meeting to be held at Statler Hotel, Cleveland. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Apr. 11-13—

Society of Automotive Engineers Inc. Aeronautic and air transport meeting to be held at Hotel New Yorker, New York. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Apr. 11-15—

American Society for Metals. Western metal congress and exposition to be held at Shrine Civic Auditorium, Los Angeles. W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, Ohio, is secretary.

because the element has MORE SURFACE

Additional surface for heat dissipation means higher watt ratings for Ward Leonard Ribflex Resistors, 85% to 95% higher than ordinary wire-wound resistors of same size.

Whether for continuous or intermittent duty, the high watt rating and low ohmic values make them first choice for a wide variety of heavy duty applications.

Write for Resistor Catalog. Ward Leonard Electric Co., 58 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC COMPANY

Result-Engineered Controls

RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

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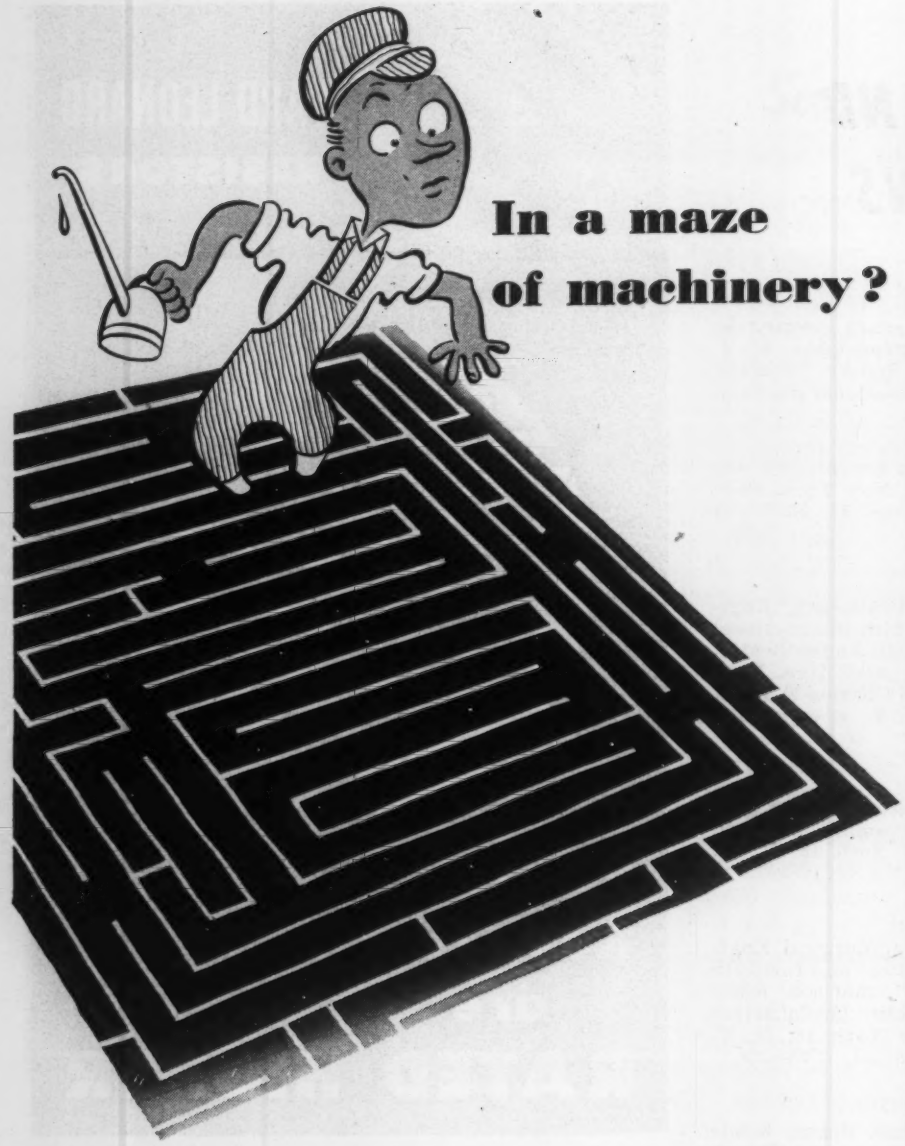


Manzel Force Feed Lubricators penetrate the maze to force just enough of the right type of lubricant automatically to every point that requires lubrication.

Manzels save the initial cost many times over each year ...in labor, in oil consumption, and in longer lasting equipment on most of the leading engines, compressors, pumps, presses and other heavy machinery. Or they can be installed on your present equipment.

A Manzel engineer will gladly give you technical assistance on your lubrication problems. Write us now.

Manzel Inc. now supplies repair parts for all models of Bowser and Torrington Lubricators.

Builders of HIGH PRESSURE METERING PUMPS Since 1898

Manzel INC.

276 Babcock St.
Buffalo 10, N. Y.

BUSINESS AND SALES BRIEFS

FORMERLY executive vice president of the Twin Disc Clutch Co., John H. Batten has been elected president. P. H. Batten, founder of the company and former president, has resigned that position to devote his time to chairmanship of the board of directors.

♦

An atomic power division has been formed by the Westinghouse Electric Corp., according to a recent announcement. Manager of the division will be Charles H. Weaver, formerly industrial manager of the company's central district. Concurrently, Westinghouse has purchased the Sunnyvale, Calif., plant previously leased from the Joshua Hendy Iron Works.

♦

R. C. Brown has been appointed director of sales for the Foote Bros. Gear and Machine Corp. Mr. Brown will have charge of sales and promotion of all company products.

♦

New branch sales office has been opened in Tulsa, Okla., by Cutler-Hammer. The office, under the management of B. R. Stratton, is located at 533 Mayo Bldg.

♦

According to a recent announcement Howard M. Dawson has been elected president of Jessop Steel International Corp. This organization, located at 75 West St., New York, is a wholly owned subsidiary of the Jessop Steel Co.

♦

Plans have been made by the Goodyear Tire & Rubber Co. for a fifty per cent conversion of its synthetic rubber manufacturing facilities for the production of cold rubber.

♦

Appointment of L. G. Maechtlen to the post of general sales manager has been announced by the Square D Co., Western Division. Mr. Maechtlen was previously works manager of the Valley Blvd. plant.

♦

The American Brass & Copper Co., Oakland Calif., has been appointed a specialty distributor of Reynolds

Torrington Needle Bearings

Keep Upkeep Down

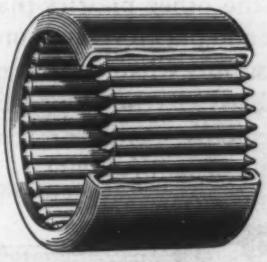
in "Caterpillar" Diesel Tractors

Heavy farm chores and tough construction jobs are a matter of course for "Caterpillar" Diesel DW10 Tractors. One feature owners like is a rugged design needing little upkeep. In governor, brake pivot shaft, steering gear and steering bellcrank, long service life is secured with efficient Torrington Needle Bearings.

The bellcrank application in steering control shows how these high-capacity, anti-friction units fit into compact designs. Two Needle Bearings mounted with close fits keep mating parts in alignment. Freedom from wear maintains close bearing clearances and eliminates the need for readjustment.

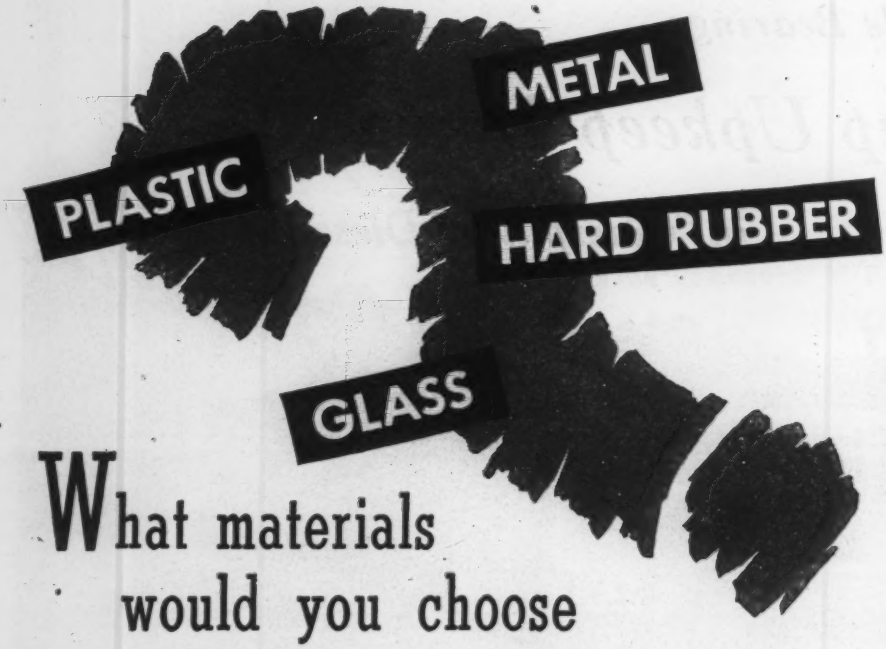
Related parts of the assembly are simple—a plain machined bore for a housing, a hardened and ground shaft for an inner race. Fabrication is easy, and installation a quick arbor press operation. No retaining devices are needed. Such Needle Bearing features help keep manufacturing costs down.

Machinery you build or operate can be improved in operation and service life with Torrington Needle Bearings. Consult our engineers on your specific application requirements. THE TORRINGTON COMPANY, Torrington, Conn. or South Bend 21, Ind. District offices and distributors in principal cities.



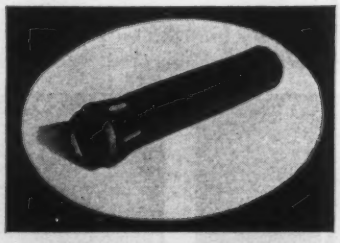
TORRINGTON *NEEDLE* **BEARINGS**

Needle • Spherical Roller • Tapered Roller Straight Roller • Ball • Needle Rollers

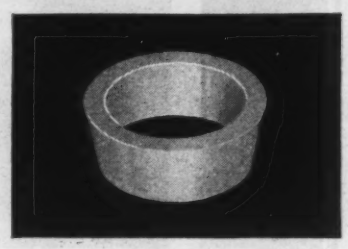


What materials would you choose for these parts?

1 INDUSTRIAL FLASHLIGHT CASE: Must be tough, good-grip, non-corrosive, oil-resistant surface. Should be electrically insulated. Plated, painted, imitation leather surfaces had been tried, but they corroded, chipped, or peeled. What material would *you* use?



2 Tapered gasket ring, exposed to acids, alkalies and essential oils, must impart no taste or odor to solutions. Must be free from "cold flow" for tight seal through a temperature range from 0° to 100° F. What material would *you* pick?



Answers: No. 1—Ace hard rubber, molded around brass tube, gives insulated, practically indestructible flashlight. No. 2—Ace Parian (polyethylene) is ideal for this gasket ring.

Yes, sometimes it's hard rubber, and sometimes it's one of the other plastics that's best. Ace, with many hard rubber and plastics compounds to choose from, is fully equipped to supply whatever you need. If you want this kind of impartial advice from your molder, select American Hard Rubber Company. Send for free 60-page Ace Handbook—a gold mine of helpful data.

ACE
Since 1851
HARD RUBBER and OTHER IMPORTANT PLASTICS
AMERICAN HARD RUBBER COMPANY
11 MERCER STREET • NEW YORK 13, N. Y.

aluminum products. The company will handle mill products. Another California firm, Western Metals & Supply Co., San Diego, was also made a mill-products distributor.

♦

With offices at 700 W. 5th St., Charlotte, N. C., A. T. Allison has been appointed district manager of the Trumbull Electric Mfg. Company's Southeast sales district. At the same time, H. S. Hill has been appointed manager of the Schenectady office. Appointed manager of the switch, breaker, control sales of the Trumbull Electric Mfg. Co. is W. A. Edwards, while Y. T. Chaney has been made manager of distribution systems sales.

♦

Expansion program involving over $200,000 has been undertaken by Kennametal Inc. New building being erected will provide 6000 square feet of plant space while laboratory addition will include 1600 additional feet of space.

♦

Field sales organization of Telechron Inc. has recently been augmented by the appointment of D. E. Perry to the staff of its San Francisco office. Mr. Perry will make his headquarters in Los Angeles and cover the Southern California area. Concurrently, W. D. Crelley has been appointed marketing manager of the organization.

♦

Harvey B. Merrill has rejoined the sales staff of the RCA engineering products department and has been named sales engineer of the scientific instrument group for Eastern United States.

♦

With offices in Selma, Ala., the Selma Foundry & Machine Co. has been appointed a distributor of Baldwin-Rex roller chain, sprockets and flexible couplings.

♦

Johns-Manville Corp. has opened a multi-million dollar plant at Tilton, N. H., for the manufacture of Quinterra electrical insulation.

♦

Appointment of seven sales representatives to Allis-Chalmers district offices has recently been announced. J. I. Onarheim and R. T. Ward have been assigned to the company's Milwaukee district office while Jay Seefeld was appointed to the San Antonio office. W. H. Sanford is now located at the Forth Worth office

CHECK TOLERANCES

FROM "TENTHS" TO "HUNDREDTHS"

BY SIMPLE TURN OF GRADUATION SELECTOR

Only Brown & Sharpe Electronic Measuring Equipment offers this advantage

By the simple turn of a graduation selector, you get accurate readings in the desired increment from .0001" to .00001", on Brown & Sharpe Electronic Measuring Equipment. No further manipulations! The amplifier unit below shows the range. In addition, intermediate settings can be made easily to match prescribed tolerance limits.

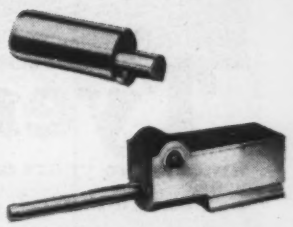
The *true linear response* of the amplifier permits accurate calibration of scale graduations. Its versatility particularly simplifies special applications in production inspection and sorting devices.

Other exclusive advantages of Brown & Sharpe Electronic Measuring Equipment include a simple, self-checking device on the External Comparator . . . no gage blocks needed . . . and a constant zero setting regardless of changes in increments of measurement. Investigate all advantages of this quality-control aid. Write for Bulletin. Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

We urge buying through the Distributor

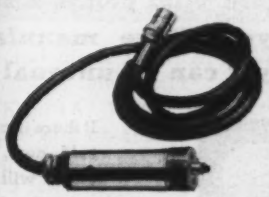
External Comparator No. 951

Range, 0-4". Simplified setting. One master only. Reversible anvil. Self-checking. Shock-protected. Diamond gaging point.



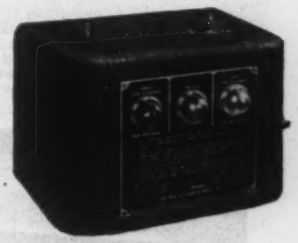
Internal Comparator Attachment No. 952

Range ½" to 2". Frictionless. No pivots to wear. One master only. One measuring point and measuring bar serve any plug.



Gage Head Cartridge No. 953

For mounting in jig or fixture. Its range of measurement is .002" with a small added over-travel which measuring point makes. Frictionless. Dust and moisture proof.



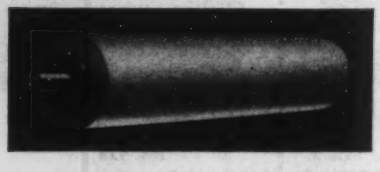
Signal Light Attachment No. 938

Optional Equipment. Speeds operations. Provides visual indication of work size. Easily and securely attached.

BROWN & SHARPE

Tyer has been doing things with rubber for ninety-two years and during that time has made many contributions to the art. In earlier days Tyer originated white rubber and elastic webbing. During the late war Tyer's contributions ranged from giant rubber pontons to tiny ear plugs made to a tolerance of one thousandth of an inch. Since the war Tyer has resumed its leadership in service to industry. Many of the country's finest and most famous products have at one or more vital points a rubber part made by Tyer. These manufacturers know that Tyer can do unusual things with rubber.

Twenty years' experience, the best engineering service, exacting quality control and highest quality compounds have won us a fine reputation among users of rubber-covered rolls.



If there is a rubber part in your product (old, new, or proposed) Tyer technicians will give you the utmost cooperation in putting all our experience at your service. Ask the Tyer representative. Write to us in Andover or to the nearest branch. *

Tyer RUBBER COMPANY

* ANDOVER, MASSACHUSETTS

159 Duane St., NEW YORK 189 W. Madison St., CHICAGO

and A. J. Mestier Jr. is petroleum sales representative in the New York office. Sales engineer at the Grand Rapids, Mich., office is R. E. Bender and J. N. Banky is working at the Chicago office of the company.

♦

New research laboratory has been built at the Reading plant of the Carpenter Steel Co. to further accelerate the company's development of alloy steels. This metallurgical laboratory is intended to provide improved customer service and will be devoted to the improvement of present steels and the development of new ones.

♦

Main line of manufacture of the Standard Machine Co., Providence, R. I., has been acquired by the Fenn Mfg. Co. of Hartford. Operation will shortly be moved to the Hartford and New Britain plants of the new owner.

♦

According to a recent announcement, Philip Diamond has been appointed application engineer for the International Rectifier Corp. Mr. Diamond was formerly in the switchboard design section of the Westinghouse Electric Corp.

♦

Formerly Pacific Coast manager for the Parker Appliance Co., Paul Locklin has been appointed Western manager of engineering service for Saval Inc. Mr. Locklin replaces J. E. Flickinger who has resigned to open his own sales agency.

♦

Associated with the Glidden Co. since 1942, James C. Rankin has been promoted to the post of executive assistant. Mr. Rankin was formerly manager of specialty sales.

♦

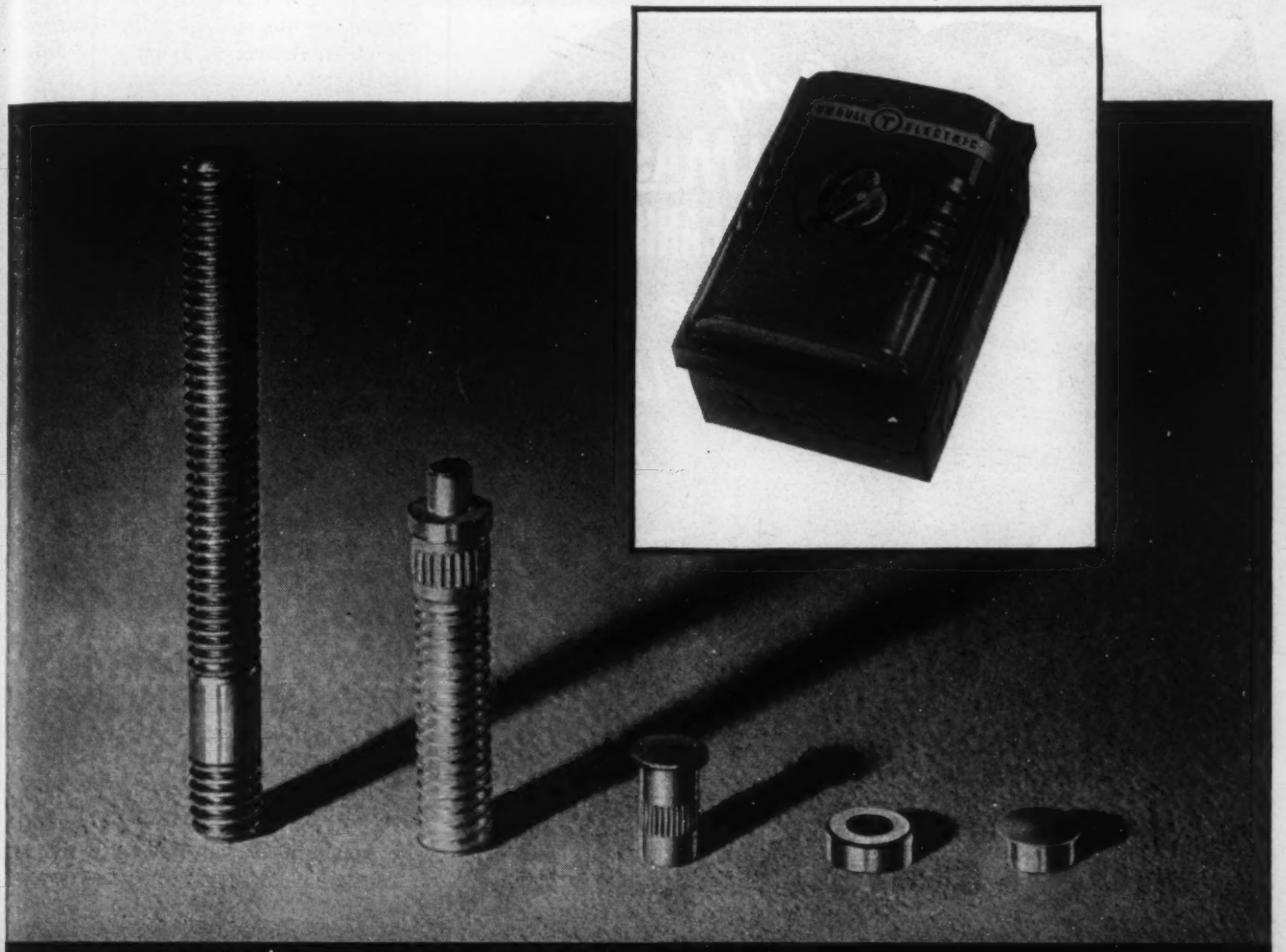
Name of the Airco Export Corp. has been changed to Airco Corp. (International) in order to reflect better its import-export operations. Change does not affect the function or corporate structure of the firm.

♦

Synthetic rubber plant operated by United States Rubber Co. at Naugatuck, Conn., is being equipped to produce cold rubber. About ten per cent of capacity of this Reconstruction Finance Corp. owned plant will be devoted to the manufacture of this new synthetic.

♦

Previously Philadelphia sales representative of Joseph T. Ryerson & Son Inc., Frank W. Eichman has been appointed sales manager of that office. The Ryerson Corp. has simul-



A CASE HISTORY SHOWING THAT

REVERE FREE-CUTTING COPPER SAVES MONEY

IF your product requires machined copper parts, it will pay you to investigate savings in machining costs made possible by Revere Free-Cutting Copper Rod. We would suggest that you make trial runs of this metal to prove what it will do under your own shop conditions. That was the procedure followed by The Trumbull Electric Mfg. Co., Plainville, Conn., with these results:

Part #18107 and 18108, contacts for the Type D switch illustrated, were designed around this alloy. Trumbull states: "On both these parts we found we could make them in one operation instead of two. That is, due to the smooth free cutting of the metal, it was unnecessary to perform a facing operation . . . Our screw machine foreman advises that, in his opinion, both these parts could be made four times as fast as out of ordinary electrolytic copper rod."

#3731, 60 amp. post stud.—5,760 pieces run in 19.6 hours with no machine down-time; 10,425 pieces of ordinary copper rod run in 66.6 hours with 11.8 hours machine down-time. In addition to the extra time required, three sets of dies were used for the regular rod. "The savings of the free-cutting material over ordinary copper were figured at $1.81 per thousand, including in these costs both material and direct labor."

#16552, space washer. "Savings per thousand over electrolytic copper were 77¢. This figure included the material difference and direct labor. In addition, there was an 18% saving in machine down-time."

#K-60-1A, 70-200 amp. stud. "The use of Free-Cutting Copper Rod on this part very definitely increased production and practically voided machine down-time."

In a letter to Revere, Trumbull added: "In general, at least for most of the parts we have used, we find that there is at least a 25% saving in machine time of free-cutting over regular copper. In addition, the workers are enthusiastic about this material, particularly when running studs, because of the fact that it is no longer necessary for them to keep a constant close watch on the machine to see that the turnings do not become tangled up with the moving parts of the machine."

The Trumbull experience is being duplicated in other machine shops. If you have not tried this Revere Metal, we suggest you get in touch with your nearest Revere Sales Office.

REVERE

COPPER AND BRASS INCORPORATED

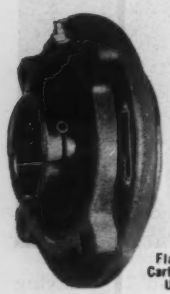
Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

• • •

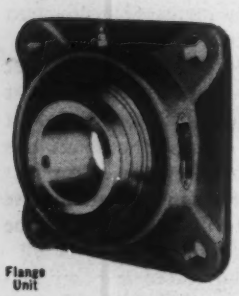
Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y. — Sales Offices in Principal Cities, Distributors Everywhere.

Important Features



Beyond the drawing board — *years from now* — the continued quiet and dependable operation of SealMaster units will amply justify their selection today. In every essential, SealMaster Ball Bearings contribute to smoother performance and low-cost maintenance. The five *important features* tell why:

1. **Permanently Sealed** — Dirt is excluded by the centrifugal flinger seals which also retain lubricant and prolong bearing life.
2. **Self-Aligning** — Shaft misalignment cannot distort the seals. Bearing unit, including seals, is independent of the housing.
3. **Pre-Lubricated** — Pre-lubricated at the factory, all SealMasters come ready for immediate use.
4. **No Housing Wear** — Patented locking pin prevents rotation of outer race in housing and positions bearing for re-lubrication.
5. **Quiet Operation** — Accomplished only by the SealMaster combination of deep-grooved, close-fitting, lapped ball races and balls and felt-lined seals.



Write for Catalog No. 845 which contains sizes, dimensions and complete engineering data.

BEARING DIVISION

STEPHEN S-A DAMSON

MFG. CO.

18 RIDGEWAY AVENUE, AURORA, ILLINOIS — LOS ANGELES, CALIF. ★ BELLEVILLE, ONT.

Factory Representatives and Dealers in All Principal Cities

taneously announced the appointment of C. H. Hallett as manager of sales at their Los Angeles plant.

♦

Hermann P. Good was elected president of the Gray Iron Founders' Society at the organization's annual meeting in Atlantic City. Other officers elected were John E. McIntyre, vice president; Robert G. Schaefer, secretary; and Henry J. Trenkamp, treasurer. New directors of the society are: H. L. Edinger, J. W. Simmons Jr., E. B. Sherwin, C. F. Scherer, H. D. Caylor, A. E. Thomas, and S. D. Russell.

♦

Covering the states of Oklahoma, Texas, Missouri, Kansas, New Mexico and Arkansas, R. M. Zimmerman has been appointed sales and engineering representative for the Midwest territory of Linear Inc.

♦

New branch office in Dayton, O., has been opened by Greer Hydraulics Inc. Located in the Keith Bldg., 4th and Ludlow Sts., the office is under the direction of Sumner Barton.

♦

Appointment of Robert Gray to the post of technical service engineer has recently been announced by the Leece-Neville Co. Formerly in charge of the company's experimental laboratory, Mr. Gray succeeds T. G. Pasco in the sales position.

♦

An expansion program which has more than doubled the firm's capacity now makes the Brooks Oil Co. the world's largest independent compounder of specialized industrial lubricants.

♦

New material and control department has been formed by the Panelyte Div. of the St. Regis Paper Co. Function of the division is to expedite production and improve service to customers.

♦

Formerly sales manager of the air and tools division of the Aro Equipment Corp., Ralph W. Morrison has been appointed general sales manager. Several other appointments in the sales division of the company have also been made. They include that of E. W. Iman to the post of sales manager of the lubricating equipment division, E. L. Jackson to sales manager of the industrial tool division, and M. J. Anderson to manager of the fittings division.

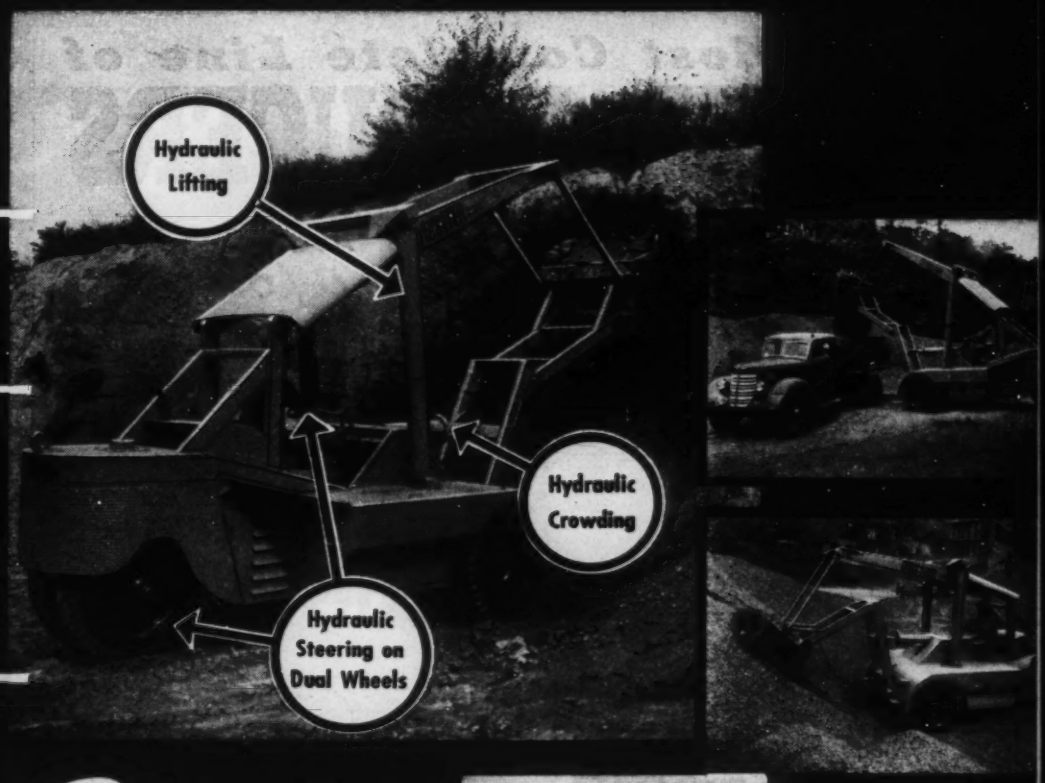
♦

Los Angeles War Assets plant for the manufacture of aluminum extru-

fast

mobile

easy to operate



Dempster-Diggster

Has VICKERS HYDRAULIC CONTROLS

High speed versatility (as exemplified by the Dempster-Diggster) is characteristic of Vickers Hydraulic Controls.

Vickers Hydraulic Power Steering Booster makes it easier to steer the Dempster-Diggster over rough terrain, than a passenger car on smooth pavement. Steering load is carried by hydraulic cylinder . . . not by the driver.

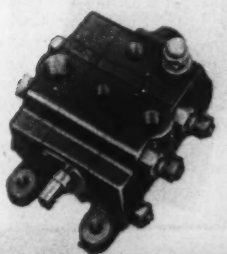
Vickers Balanced Vane Type Pumps supply oil under pressure also for actuating cylinders that lift and crowd the dipper. These pumps are exceptionally efficient and dependable; their exclusive hydraulic balance construction prolongs pump life by entirely eliminating pressure-induced loads and consequent wear.

Overload protection for the machine is provided by relief valves integral with Vickers Steering Booster and Valves. Write for descriptive bulletins.

Vickers Improved Hydraulic Steering Booster with integral overload relief valve. See Bulletin 47-30a.

Vickers Balanced Vane Type Pumps are engine driven. See Bulletin 36-12.

Vickers "Multiple Unit" Valves include relief valve for overload protection. See Bulletin 40-13.



VICKERS Incorporated
DIVISION OF THE SPERRY CORPORATION

Application Engineering Offices:

ATLANTA • CHICAGO • CINCINNATI • CLEVELAND • DETROIT
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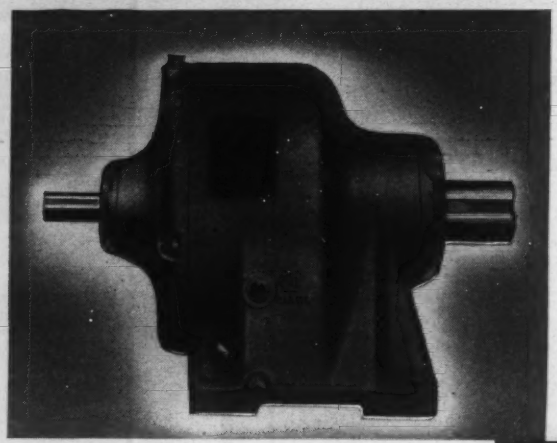
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

The Most Complete Line of
SPEED REDUCERS



Available from Any One Source

Including the Revolutionary New

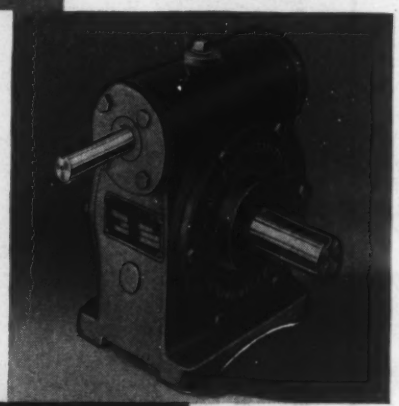
WHS WINSMITH SPEED REDUCERS

DIFFERENTIAL UNITS

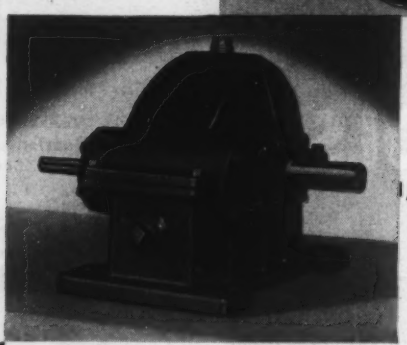
No. 31H Differential Speed Reducer

PROVIDES STILL GREATER
Economy and Efficiency
SAVES VALUABLE SPACE

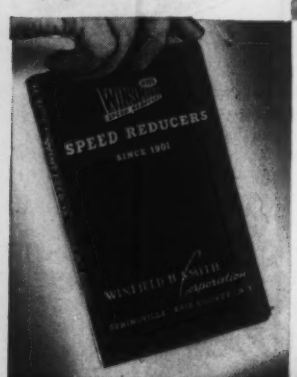
Direct Centered Load Distribution
6 SIZES . . . 1/10 to 81.5 H.P.
Horizontal and Vertical Types



(above)
"BT" SERIES
Horizontal
Single
Reduction
1/5 H.P. to 12½ H.P.



(at right)
HELICAL GEAR
Horizontal
Single Reduction
½ H.P. to 8 H.P.



Send for Our Latest
POCKET-SIZE CATALOG

It covers our complete line . . . including the new, space-saving patented Winsmith Differential Speed Reducer. Gives ratios, horsepower, torque, overhung load capacities . . . includes valuable reference material and comprehensive Engineering Section. For Catalog 148, please write on your letterhead stating position.

See our CATALOG in SWEET'S FILE

WHS WINSMITH SPEED REDUCERS

WINFIELD H. SMITH CORPORATION

MEMBER OF AGMA

16 Elton St.
SPRINGVILLE . . . Erie County . . .. . NEW YORK

sions has been sold to the Harvey Machine Co. of that city. Facilities include a 379,000 square-foot building.

♦

Office and plant of the Adamas Carbide Corp., formerly of Long Island City, N. Y., have been moved to Harrison, N. J. New plant at 1000 S. 4th St. is more than four times the size of that in the previous location.

♦

Two new appointments have been made by the Leland Electric Co. P. G. Ganley has been given the post of vice president in charge of sales and J. C. Hiatt has been appointed district manager in Milwaukee.

♦

Previously sales manager of the Hydraulic Div. of the New York Air Brake Co., Dean W. Johnston has been appointed manager of sales and distribution of Power Plus Products Co., Detroit.

♦

Philadelphia office has been opened by the Interstate Steel Co. Located at 6701 N. Broad St., the office is under the direction of Saul Bradburd.

♦

Three new appointments to positions of zone sales managers have been made by the Sherwin-Williams Co. E. H. Steger will be in charge of the new textile industrial zone with headquarters in Charlotte, N. C. and D. S. Shimp will head the South-Eastern zone with headquarters in Atlanta. Managing the Gulf zone will be J. R. Stevenson with headquarters in Dallas, Tex.

♦

Representing the Bearings Div. of the Torrington Co., Richard C. Lawton has been appointed district engineer in the Western New York State territory. His headquarters are in Rochester. Other recent appointments include L. A. Toth as district manager of the Dallas, Tex. office with J. H. Williams assisting him as district engineer. J. N. Wholean has been appointed district engineer for the Milwaukee office, working under D. E. Lewis.

♦

Election has been announced of Lee Mullen as vice president in charge of sales of the Globe Steel Tubes Co. Previously, Mr. Mullen was general manager of sales for the company.

♦

Sales office in Newark, N. J. has been opened by Hydraulic Equipment Co. The office, located at 1060 Broad

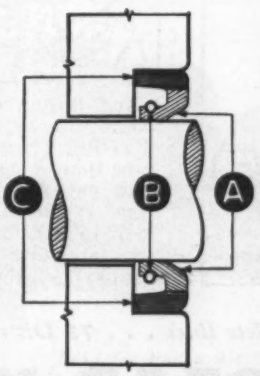
What—...AN OIL SEAL THAT'S *Flexible?*

TWIST IT . . . squeeze it . . . drop it . . . hammer it—the new one-piece concentric molded J-M Clipper Seal has plenty of give and take to help it stand up in service.

This flexibility has its advantages. The Clipper Seal's hard, tough outer heel, for example, is resilient enough to conform even to a slightly out of round cavity. Yet the soft, pliable *inner* lip always maintains a light, but positive sealing pressure on the shaft, with minimum wear on the seal.

The simple design of Clipper Seals also assures quick, easy installation, and permits removal without damage so that the seal may be used again. And because Clipper Seals are entirely non-metallic, they eliminate any possibility of electrolysis or corrosion.

Clipper Seals are made in both split and endless types . . . are available for shafts in sizes from ¼" I.D. up to 68" O.D. They are for sealing against oil, grease, water, coolants at operating temperatures up to 450°F. Write for folder PK-31A to Johns-Manville, Box 290, New York 16, N. Y.

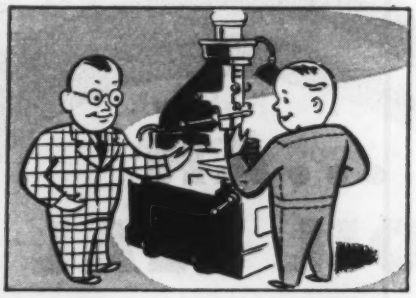


Here's how *Clipper Seal* works:

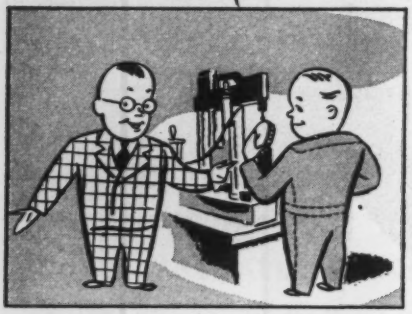
The lip (A) is held in light but firm contact with the shaft by means of a specially designed garter spring (B). Pressure on shaft is carefully pre-determined to minimize wear, yet effectively seal against leakage. The heel (C) provides a press fit in the cavity, assuring a tight lubricant-retaining seal at this point also. This design is readily varied to meet special conditions.

Johns-Manville **PACKINGS & GASKETS**

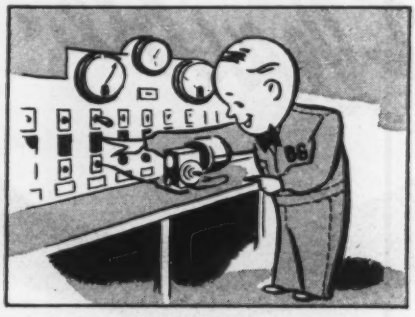
"It's QUALITY CONTROL that sold me on Boston Gears!"



"67 years of experience give Boston Gear Works a big edge in know-how and craftsmanship. They've worked out processes and techniques that build *extra* quality into their products."

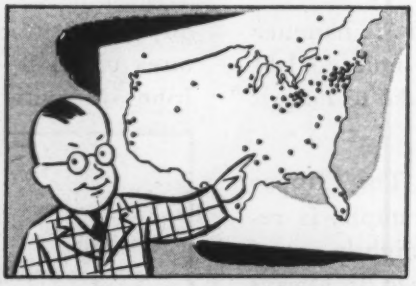


"Everything is checked and tested. Boston Gear controls its own materials and alloys . . . uses only virgin metals . . . tests its materials for hardness and tensile strength . . . tests its products for shock strength, hardness and wear."



"Every craftsman is an Inspector . . . makes sure previous operation is properly done before he starts . . . inspects his entire run and he's double checked by our elaborate Central Testing Lab."

"Engineers can design around Boston Gear stock parts with complete assurance of success . . . manufacturers can cut costs *safely* with these mass production masterpieces. Rigid inspection of all production for exacting tolerances and size of finished products is your guarantee of perfect interchangeability."

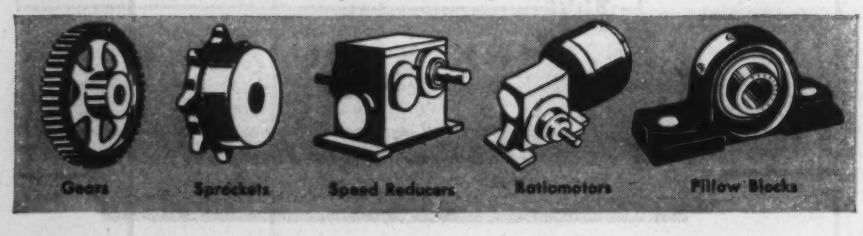


"And Boston Gear products are sold coast to coast through 71 DISTRIBUTORS. There's one within fast shipping time of *your* plant . . . and you can now buy most Boston Gear products *right off the shelf!* See our THOMAS' REGISTER insert under Gears & Pinions for your nearest source . . . or write for list of Authorized Distributors.

One of the world's most complete lines . . . 71 Distributors in major cities

BOSTON GEAR WORKS

91 Hayward St., Quincy 71, Mass.



St., will be under the supervision of Richard Andrews, Eastern sales manager.

♦

J. Y. Richards has been appointed Chicago district sales manager for the Joy Mfg. Co. He was formerly assistant manager of the Chicago district.

♦

William W. Hickey now represents the Flexible Steel Lacing Co. in the New England and New York territories. He succeeds John Ramsey who has been transferred to the company's executive sales office in Chicago.

♦

With offices in the Temple Court Bldg., Denver, Floyd H. Boyder has been appointed representative of Ampco Metal Inc. Mr. Boyder will handle all Ampco products, with the exception of welding electrodes and centrifugal pumps, in the state of Colorado as well as Laramie county, Wyoming.

♦

Expansion of the Douglas Aircraft Co. into the pressed metal field has been announced. To do this a separate division known as the Metal Products Div., has been set up under Harry Woodhead. Prior to coming with Douglas, Mr. Woodhead was president of Consolidated-Vultee Aircraft Corp.

♦

Appointed direct sales representative by the Rapids-Standard Co. Inc., Richard R. Williams will have his office at 663 Spitzer Bldg., Toledo. He will cover the Toledo territory.

♦

Announcement of the appointment of two new agencies to handle sales of cylinders and other pneumatic devices has been made by Mead Specialties Co. These agencies are R. M. Wright Co., 7401 DuBois St., Detroit and Jackson-Walter Co., 210 N. 13th St., Philadelphia. The Wright Co. will represent Mead in Michigan while Jackson-Walter Co. will cover eastern Pennsylvania, lower New Jersey, and the states of Delaware and Maryland.

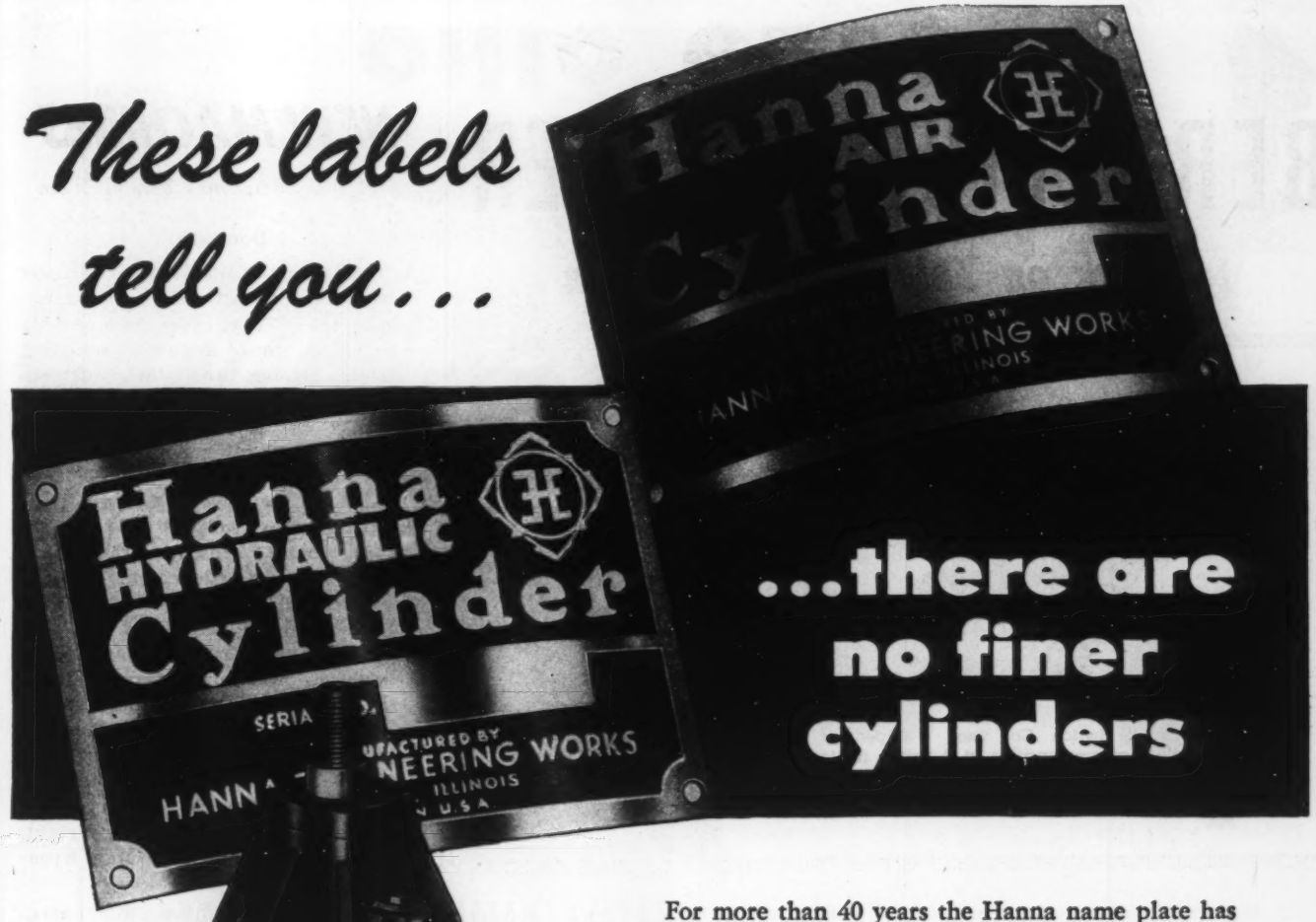
♦

Expansion of laboratory and warehouse facilities by the Jones & Laughlin Steel Corp. is nearing completion. The $1,000,000 Pittsburgh project is intended to improve customer service.

♦

Headed by Howard F. MacMillin, former president of the Hydraulic Press Mfg. Co., the MacMillin Engineering Corp. of Chicago will represent Gerotor May Corp. in that area. Offices of the organization are at 208 S. LaSalle St.

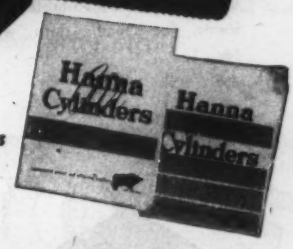
These labels tell you...



Hanna Air Cylinders are designed for operation up to 110 p.s.i., and to 250 p.s.i. with minor modifications . . . in sizes from 1½" to 20" diameters.

For more than 40 years the Hanna name plate has been a familiar trademark-of-quality throughout industry. Those who demand the best in cylinder performance, reliability and long life specify Hanna Air and Hydraulic Cylinders for 1001 uses . . . to push, pull, lift, press, clamp or control . . . for the products they build for sale . . . to save manual labor and increase production in their own plants. There are standard Hanna Cylinders to meet most mounting requirements . . . to solve many of *your* problems.

Hanna Hydraulic Cylinders may be operated at working pressures up to 1500 p.s.i. . . . available in a variety of types and capacities.



Send for Hanna Air and Hydraulic Cylinder Catalogs

Hanna Engineering Works

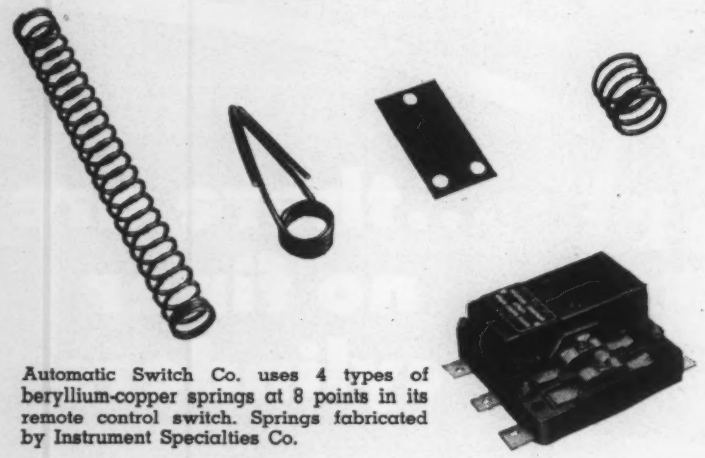
HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES . . . RIVETERS

1765 Elston Avenue, Chicago 22, Illinois

Put High Performance

BERYLLIUM-COPPER

to work on Your Spring Problem



Automatic Switch Co. uses 4 types of beryllium-copper springs at 8 points in its remote control switch. Springs fabricated by Instrument Specialties Co.

By taking advantage of the special properties of BERYLCO 25S, The Automatic Switch Company has built high efficiency into remote control switches while cutting assembly costs.

4 Springs . . . . . 4 Functions

- *LONG CORE SPRING* . . . Non-magnetic for operation in solenoid field and corrosion-resistant for out-door installation.
- *SHORT COMPRESSION SPRING* . . . Maintains desired contact pressure without set at high temperatures.
- *TORSION SPRING* . . . High strength for maximum operating power.
- *FLAT SPRING* . . . Dimensional control through fixture heat-treatment gives accurate positioning of arcing contacts.

If, in addition, your spring problem involves freedom from drift, electrical conductivity or close control of free length, coil diameter and load-deflection rate—look to beryllium-copper for the solution.

BERYLCO 25S is available in strip, wire and rod forms. For specific data, write for Technisheet No. 2.

BERYLCO BERYLLIUM

The **BERYLLIUM CORPORATION**

Dept. 2M, Reading 1, Pa.

NEW MACHINES

And the Companies Behind Them

Domestic

AUTOMATIC CLOTHES WASHER. Basket bounces vertically during washing; spin dries. Total cycle time of 18½ to 27½ min includes washing, triple rinsing and damp drying. Drive mechanism employs no gears. Safety switch permits interruption of cycle at any point. Requires 7 gal hot water for each wash, 24½ gal total per cycle. Loaded from top; includes two-position temperature control. Apex Electrical Manufacturing Co., Cleveland.

Industrial

HAND VACUUM CLEANER. Light duty model. Blower nozzle furnished; attachments for vacuuming, spraying and drying. Uses ½-hp motor giving air velocity at nozzle of 18,000 fpm, suction air volume of 120 cfm through 1½-in. hose. Rated at 28-in. water lift. Weight, 8¼ lb. Ideal Industries Inc., Sycamore, Ill.

CRANE AIR CONDITIONER. For operation in ambient temperatures to 130 F; maintains cab temperatures at 80 to 85 F in summer, 68 to 72 F in winter. Mounted vertically alongside crane cab. Removes dirt, dust, gas fumes, and odors from air discharged into cab. Uses Freon 114 refrigerant. Dravo Corp., Pittsburgh.

Manufacturing

ARC WELDER. Industrial and shop ac models. Feature four-coil transformer with movable magnetic shunt, correct ratio of open circuit to arc voltage. High potential secondary circuits provide ample dielectric strength. Stepless full-range output control. High reactance windings permit low-current welding. National Cylinder Gas Co., Chicago.

PNEUMATIC RIVETER. Adjustable impact, rotating hammer works vertically toward either stationary or elevating anvil. Hammer piston threaded to fit all standard types of peins. Automatic timer controls time of hammering cycle. Hill Machine Co., Rockford, Ill.

INDUCTION HARDENER. For gears. Automatically heats and quenches one tooth at a time; then indexes to next tooth. Handles gears to 20 in. diameter, with 12 in. face. Mounts

OHIO GEAR

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Hardware & Supply Co.
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Bearing & Transmission Co.
*Hagerstown, Md.
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*Los Angeles, Calif.
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Alfred Halliday
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Industrial Supply Co.
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Patron Transmission Co. Inc.
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Robert L. Latimer Co.
*Philadelphia 6, Pa.
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J. W. Minder Chain & Gear Co.
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*Montreal, Quebec, Canada
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*Stocks Carried.

Nationally known Ohio Gears and Speed Reducers are nearer to you than ever before. Alert distributors, with comprehensive stocks offer the famous Ohio Gear "Off the Shelf Service" in nearly every industrial center across the continent.

No farther than your phone, you'll find Ohio Stock Gears in spur, helical, bevel, worm and worm wheel types and Speed Reducers in single and double reductions in 1/6 HP to 10 HP and in ratios from 3-1 to 3200-1. You'll also find sound, capable engineering service as well as prompt attention to your needs.

Put the money-saving advantages of Ohio Stock Gears and Reducers to work for you now. Phone the nearest distributor or write direct.

ESTABLISHED 1915

THE OHIO GEAR COMPANY

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SCREW MACHINE PARTS

Rely on this trade-mark for precision screw machine parts.

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More than a hundred automatic screw machines are ready to make your parts now.

If your part is small (3/64") or large (5 1/2") we have the machines to do the job. We also have complete, turret lathe, milling machine, grinding and heat treating departments.

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BAR STOCK CAPACITY
3/64" to 5 1/2" diameter

ALL SECONDARY AND FINISHING OPERATIONS UNDER ONE ROOF.

CHICAGO
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PITTSBURGH
PHILADELPHIA

U·S·Automatic Corp.
Amherst, Ohio

on conventional sink table. Induction Heating Corp., Brooklyn, N. Y.

ELECTRIC CHISEL MORTISER. Portable. Adjustable to various sizes of mortise. Can be used as bench drill, hand drill, bench grinder, and polishing tool by using proper accessories. Steel drilling capacity, 1/8-in. diameter. S. Wolf & Co., Ltd., London, England.

FLASH WELDER. For joining band saw blades 2 in. wide. Special inserts permit joining wire, drill rod, bars, or flat stock 5/16-in. diameter. Weld cycle motor controlled and fully automatic. Attached grinding wheel unit for preparing material to be welded and removing flash. DoAll Co., Des Plaines, Ill.

Materials Handling

AUTOMATIC WEIGHER. Beam type machine prints weight on card and visually indicates dormant loads. Capacities, 1000 to 100,000 lb. Streeter-Amet Co., Chicago.

DRUM-CARRIER ATTACHMENT. For fork trucks. Picks up, carries and tiers 2 or 4 55-gal drums. Fits over top of drum, hydraulic shoes clamp drum using hydraulic power from fork truck lifting mechanism. Clark Equipment Co., Battle Creek, Mich.

ELECTROMAGNET. Removes tramp iron from material carried on conveyors or in chutes. For applications where heavy burdens or fast belt speed make standard magnetic separators ineffective. Intensity of magnet field, 200 gauss at 24 in. from belt surface. Rectangular magnet removes tramp iron from 42-in. belt delivering 1000 tons coal per hour. Dings Magnetic Separator Co., Milwaukee, Wis.

AUTOMATIC COUNTER AND STACKER. Counts flat products up to 200 per min; stacks, and transfers pile to conveyor system. Handles pieces from 9 to 82 in. wide, transfers counted stack in ½-sec. Electrically operated. Superior Punch Press Co., Cleveland.

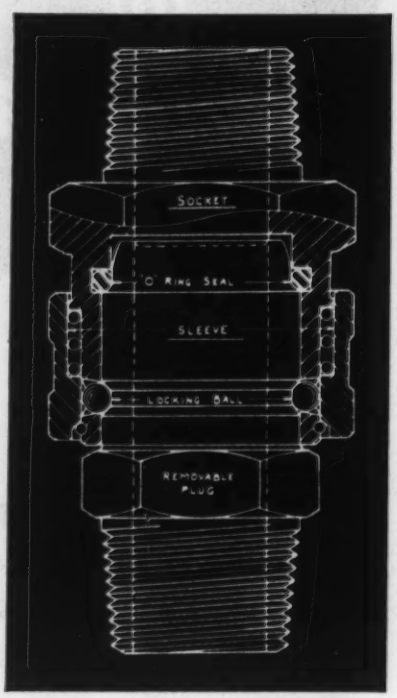
LIFT TRUCK. All-electric or gas-electric powered. Capacity, 20,000 lb. Platform, 144 by 32 in. Min. platform elevation, 11½ in.; max., 17 in. Platform hydraulically operated. 4 wheel sets; hydraulic steering. Turning radius, 99½ in. Weight, 8000 lb. Elwell-Parker Electric Co., Cleveland.

ELECTRIC FORK TRUCK. Capacity, 15,000 lb. Telescopic and nontelescopic models. Telescopic type has lifting height of 123 in., collapsed height of 83 in. Reinforced frame and low center of gravity give maximum stability and safety. Forward and reverse travel. Brakes

USE "O" RING SEALS

(The modern packing method)

FOR SIMPLICITY • RELIABILITY
LOW COSTS • SPACE SAVINGS



"O" Ring Seals made possible this simple, straight through, quick disconnect coupling by THE HANSEN MANUFACTURING COMPANY of Cleveland, Ohio.

The end of the removable plug is tightly sealed by the "O" Ring when the plug and socket are in the locked position. Yet the plug can be removed and re-connected thousands of times without leakage.

Think of how complicated, bulky and costly this coupling would have been had conventional packings been used.

You, too, may have a problem that can easily be solved by using simple "O" Ring designs. For complete Engineering Data write for our "O" RING HANDBOOK.

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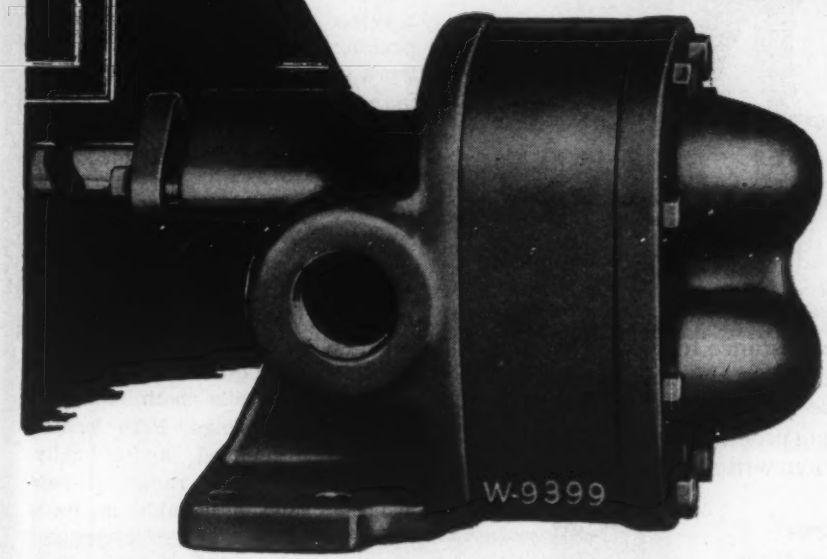
THE GOOD RIGHT HAND OF INDUSTRY

It's bronze . . . *for pumping mildly corrosive liquids*



Worthington GB Rotary Pump—Bronze

Now you can have, in an *all-bronze* rotary pump, the many advantages of the famous Worthington GA All-Iron Rotary Pump—the pump with the double helical gears and four large force-feed-lubricated bearings.

The new GB All-Bronze Rotary Pump is exactly the same—same construction, same action, same capacities—as the GA, except that it's bronze to handle a wider range of fluids.

This small but rugged GB All-Bronze Rotary—displacements to 56 gpm against low pressures—handles mild acids, alcohol, beverages, salt brines, fresh and sea water, and water solutions, without corrosion or contamination of the liquid.

Send coupon for free bulletin W-484-B2 Worthington All-Bronze Rotary Pumps.

For *other* services—fuel oil, gasoline, lube oil, dyes, tar, asphalt, etc.—specify the All-Iron GA. And, on *any* pumping problem remember *there's more worth in Worthington.*

Immediate Delivery

For longer pump life, call on your Worthington distributor, your local "good right hand of industry," listed in Thomas' Register. His local stocks are supported by factory stocks for prompt delivery.

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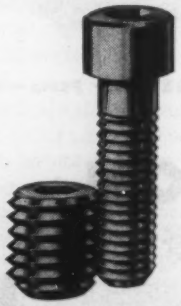
THERE'S ALWAYS SOMETHING NEW IN ALLENS

The Allenut* is the precision counterpart of Allen Hex-Socket Cap screws. A "ready-made" threaded hole, one end tapped to a Class 3 fit, the opposite end with a double hex socket for wrenching. Greater holding power, easier assembly, more compact design, all are made possible by the new Allenut*, now available from No. 4 to 1", NC or NF threads. Here's another instance to prove that the Allen dealer is the man to see first for the answer to a precision fastening problem. For technical information, write the factory direct.

Popular sizes of Allen Hex-Socket Set Screws and socket head cap screws now standard and available in stainless steel from distributors' stock. New methods, new alloys, new designs are constantly being investigated, and the best put to use to make every Allen socket screw, dowel pin and pipe plug the best money can buy.



WARNING
Allen-TYPE screws aren't necessarily Allen-MADE. Be sure to get genuine ALLENS in the black and silver box.

*Patent applied for

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ALLEN (ALLEN HEAD)

Hartford 2, Connecticut, U.S.A.
NEW YORK, CLEVELAND, DETROIT, CHICAGO, LOS ANGELES

released by depressing brake pedal. Five lubrication points. Lewis-Shepard Products Inc., Watertown, Mass.

DUAL-TIRED FORK TRUCK. Wide drive axle mounting dual pneumatic tires for trucks where operations involve lifts above 144 inches. Provide more stability and greater safety. Clark Equipment Co., Battle Creek, Mich.

FORK TRUCK. Light-weight, battery operated, 2000-lb capacity. Wheelbase, 42 in.; width, 30 in.; right-angle turn requires 76½ in. plus length of load. Weight, 3850 lb. Three speeds forward and reverse. Interlock between brake and controller prevents both being on at same time. Baker-Raulang Co., Cleveland.

Metalworking

MULTIPLE DRILLING MACHINE. Drills, countersinks, and reams 5 holes in flanges of rear axle shafts for automobiles; 225 pieces per hour. 4-station, power-operated, index table type machine has independent floating work-holding fixtures insuring concentricity between holes and pilot diameter. Feed and rapid traverse hydraulically operated; pushbutton control of automatic work cycle. Cross Co., Detroit.

INJECTION MOLDING MACHINE. Capacity, 3-oz. Clamping pressure, 75 tons, taken on four 3-in. strain rods. Material injected at 13,900 psi max. Handles molds 12 by 15 by 12 in. Combines hydraulic loading with electrical heating and controls. Sliding safety gate cover. MacRay Engineering Co., Cleveland.

CRANKSHAFT FACING MACHINE. Faces and center drills both ends of crankshaft forgings. Part located manually, clamped hydraulically. Adaptable to wide range of part lengths, fully adjustable in feeds and speeds. Capacity, 47 pieces per hr. Floor space, 108 by 70 in. Snyder Tool & Engineering Co., Detroit.

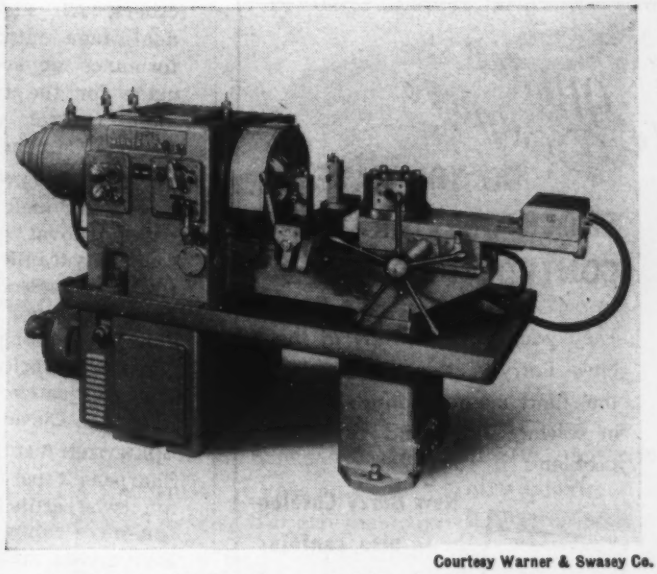
WELDER. Light-weight, engine-driven, dc welder. Max. welding current, 250 amps. Powered by air-cooled engine coupled to generator with steel-core belt drive. Built-in auxiliary power outlet for 110-volt operation of lights and power tools. Overall length, 44⅛ in.; width, 24½ in.; height, 35⅜ in. Can be trailer mounted. Weight, 660 lb. General Electric Co., Schenectady, N. Y.

WELDERS. Line of ac welders rated from 100 to 2000 amps. Power factor correction standard equipment on most models, optional on

What happens—

When You Give A Turret Lathe A

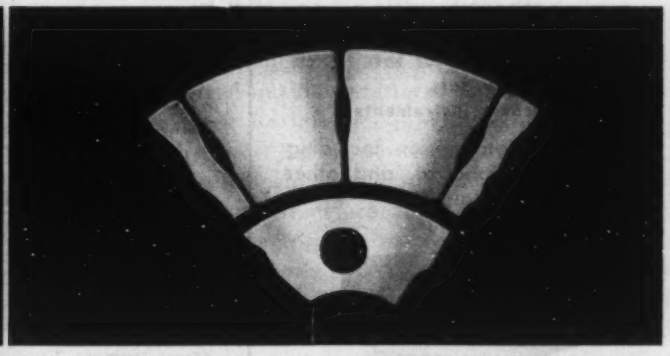
BRAKE?



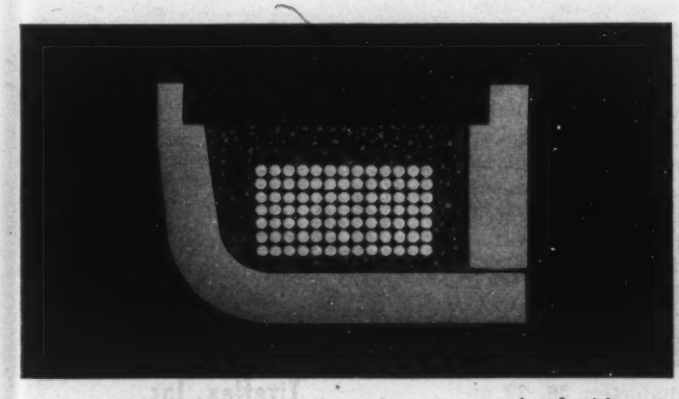
Courtesy Warner & Swasey Co.

ANSWER: You reduce machine handling time and increase production because you get fast, more fully automatic cycle operation. The W & S 16" Electro-Cycle turret lathe, especially designed for machining non-ferrous metals, uses the Warner Electric Industrial Brake. It gives lightning fast spindle stops and closer spindle positioning — that means fast load and unload of workpieces.

THE BRAKE: Note compact design . . . readily adapts to machine or motor. Unit consists of only two parts . . . one fixed and one moving. Brake is automatically self-adjusting for life. Wide range of sizes to meet various requirements. Fits N.E.M.A. standard motor shafts.



ARMATURE SECTION: Armature is only moving part. Consists of magnetic material segments welded to steel back plate . . . for unmatched heat dissipation. Heat has no effect on efficiency . . . segment expansion is linear . . . keeps full magnet contact at all times.



MAGNET SECTION: Unique electro-magnet faced with extra long-wearing, molded friction material. Power is applied through coils imbedded below. Energizing applies friction *plus* magnetic attraction for super-powerful braking or clutch action.

• Warner ICB Units* are low-cost key to more automatic, safer operation of wide variety of motors and machinery . . . give you infinite control of degree of clutch or brake action. For details or engineering assistance write: WARNER ELECTRIC BRAKE MFG. CO., Beloit, Wis.

WARNER

*ICB Unit — The trade designation for the Warner Electric INDUSTRIAL CLUTCH OR BRAKE UNIT.

Mister Designer

DO YOU HAVE A SHOCK OR VIBRATION CONTROL PROBLEM?

Then you'll want a copy of the New Barry Catalog describing the fundamental considerations in solving shock and vibration problems

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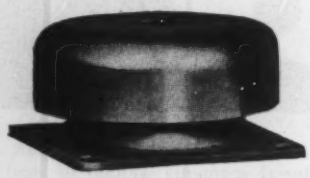
- **Descriptions**
- **Illustrations**
- **List of uses**

Typical Barrymounts shown in this Catalog are used for:

machine-tools
punch presses
motor-generator sets
motor-fan sets
electronic instruments

and many other uses—including airborne, shipboard, and other military applications.



Barrymount Type C-2000 used on Motor-generators and motor-fan sets.

BARRYMOUNTS Control VIBRATION and IMPACT

In addition to a complete line of highly engineered Vibration and Impact Isolators we offer an Engineering Consulting Service on special problems.

- **Send for New Catalog**
- **Outline Your Problem**
- **We Welcome your Inquiries**

THE BARRY CORPORATION
Formerly L. N. BARRY CO., INC.
175 SIDNEY STREET
CAMBRIDGE, MASS

others. All models equipped for dual-range output, improving performance at low heats. Provision made for the use of optional remote control equipment. Glenn-Roberts Co., Inc., Indianapolis.

INVERTED DRILLING MACHINE. Drills holes from underneath to facilitate chip removal and speed production. Hydraulic cylinders provide fast approach of drill head, slow feed rate and fast return. Work held in indexing mechanism. Self-contained lubrication system cools and lubricates drill head. Zagar Tool Inc., Cleveland.

COMBINATION TAP AND DRILL GRINDER. Sharpens taps from No. 6 to 1½ in.; twist drills from ⅛ to 1½ in. One-piece column and base casting. Belt driven spindle. Right or left-hand 2, 3 or 4-flute taps or twist drills. Dressing wheels included. Gallmeyer & Livingston Co., Grand Rapids, Mich.

MULTIPLE DRILLING HEAD. Drills 10 various-sized holes on different elevations. Grooved thrust ball bearings at thrust points in head; hardened bronze radial bearing. Geared approx. 2:1. One-piece spindles and gears turned from solid bar stock. Errington Mechanical Laboratory Inc., Staten Island, N. Y.

THREAD GENERATING MACHINE. Automatic; for machine tool lead screws, feed screws, worms. High speed steel cutters. Box type bed construction. Plain, heavy duty machine or universal machine for general production of lead screws and threads; 18, 37, 77, and 116-in. beds. George Scherr Co., New York.

HIGH-SPEED FRICTION SAW. Cuts heavy sections, such as structural members, cleanly. Remotely controlled, electrically operated feed and take-off rolls. Hydraulic forward and reverse movement of saw. Steel disk saw, 60 in. diameter, 7/16-in. thick; 1750 rpm. Includes water coolant system. United States Steel Corp., Pittsburgh.

TAP GRINDER. Double-end spindle type. Two taps may be ground at the same time. Adjustable angle of entrance taper at point. Diamond truing device included. Belt driven spindle; holes provided in base for lag screws. Gallmeyer & Livingston Co., Grand Rapids, Mich.

BROACH SHARPENERS. Two sizes for flat broaches; 8 in. wide, 32 or 65 in. long. Three sizes for "round" broaches; 6-in. diameter, 36, 72 or 84 in. long. Two universal models will handle "round" broaches 6 in. diameter, 72 or 84 in. long; flat broaches 8 in. wide, 65 or 77 in. long. 4000-rpm grinding wheel

The **Titeflex** GRANNAN LUBRICATOR

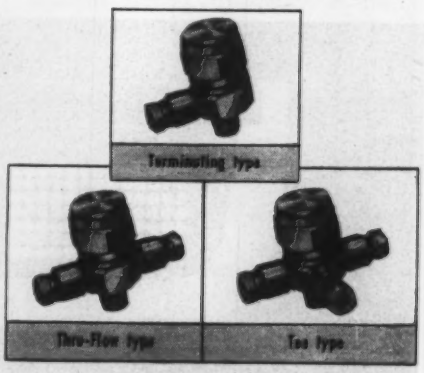
for dependable, single line Centralized Lubrication

One TITEFLEX Grannan Lubricator is used on each bearing in the machine or mechanism. All lubricators are connected to one central line (by tubing or pipe) so that when oil or grease is introduced at the central point each lubricator delivers the correct amount to each bearing in the system. Positive, dependable lubrication is accomplished in a matter of seconds, regardless of the number of bearings in the machine or machines.

Look at these ADVANTAGES

- Fully Hydraulic in Operation
- Installs Directly into Bearing (lube lines unnecessary)
- Same Valve for all Lubricants (from light oil to heavy grease)
- Wide Operating Temperature Range (satisfactory operation up to 300°F.)
- Through Flow (no cavities to retard lubricant)
- No Special Lubricant Guns Required

You will be amazed at the savings in time and lubricant when you use TITEFLEX Grannan Lubricators. Write for descriptive booklet.

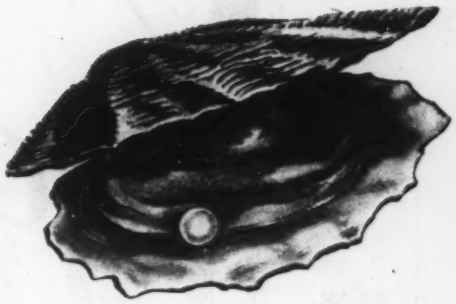


Titeflex, Inc.
532 Frelinghuysen Ave., Newark 5, N. J.

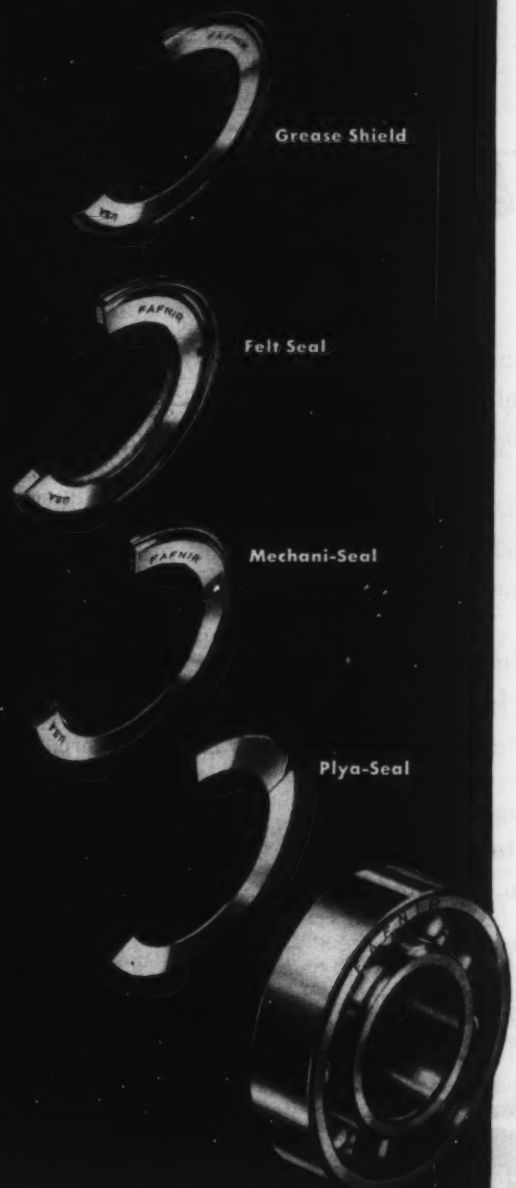
Exclusive Manufacturers of Titeflex high quality products for more than 30 years

Sales Offices { CHICAGO CLEVELAND DETROIT PHILADELPHIA LOS ANGELES BOSTON SAN FRANCISCO TORONTO

Only an oyster can make pearls out of GRIT



When an oyster yawns too wide and gets some grit in the works, it goes into the jewelry business... making pearls. But grit inside a ball bearing puts it out of business. And the conditions of an oyster's life are nothing to what a ball bearing has to put up with in construction machinery, airplanes and in textile mills and chemical plants. So devising "shells" for ball bearings to crawl into was a natural for Fafnir pioneering... beginning more than twenty years ago.



Survival of the "fittest"

In order for these seals and shields to keep lubricant *inside* the ball bearing and lock dirt *outside* they must be fitted to thousandths of an inch . . . yet the bearing must be left free-moving, unencumbered. And in the latest Fafnir development, the Plya-Seal, even this infinitesimal clearance has been abolished. It's a "wiping contact" yet the bearing's free as air. One of these bearings carries this evolution an interesting step further: it includes a grease chamber which provides lubrication for years and years of maintenance-free service. Today Fafnir-designed ball bearings can take almost any condition that industry throws at them . . . brine, steam pressure, desert heat and polar cold, dripping moisture and clouds of acid and alkali.

Need some ingenuity and interest?

Could be, there's no place in your machine for these Fafnir protected ball bearings. But there's certainly a place in your product planning for the kind of ingenuity and interest that produced all these variations on a basic theme to meet specific problems in various industries. That's the point... Fafnir's experience is not limited to just one or two industries but is industry-wide. The Fafnir Bearing Company, New Britain, Conn.

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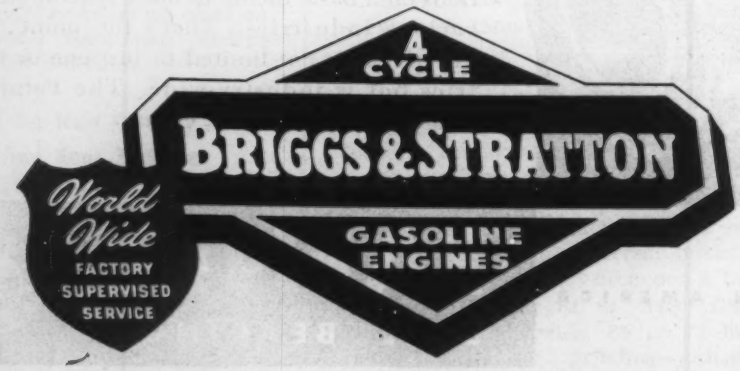
- To maintain and even raise the high standards set for materials, workmanship, methods, and precision production.
- To expand and still further improve the world-wide organization of factory approved service stations.
- To continue to be accepted as "preferred power" everywhere for industrial, construction, railroad, and farm equipment.

BRIGGS & STRATTON CORPORATION
Milwaukee 1, Wisconsin, U. S. A.



spindles. Headstocks on "round" and universal machines geared for 200 and 400 rpm. Colonial Broach Co., Detroit.

STAMPING TRIMMER. Light-duty, for cutting mild steel to $\frac{1}{16}$-in. Constant or variable speed drive through differential type transmission allows use of rolls of different diameters with no variation in peripheral speed. Min. cutting speed, 15 rpm. Whiting Corp., Harvey, Ill.

SHOP SAW. Portable. One-hp motor drives 10-in. diameter blade. Can be used as cut-off, miter, rip, or double miter saw. Attachments permit use as dado, gaining, grooving, or rabbeting machine. Roller bearing travel head rides on machined tracks inside adjustable arm. Dewalt Inc., Lancaster, Pa.

ROTARY PRESS. Automatic; Capacity, 15 tons. For highspeed cold molding. Automatic safety release and pressure equalizer prevent jamming. Adjustable for pressure, thickness of piece and speed of press. Handles pieces $1\frac{7}{16}$-in. diameter, $2\frac{1}{16}$-in. die fill. F. J. Stokes Machine Co., Philadelphia.

Power

DUAL-FUEL DIESEL ENGINE. Rated at 425 hp per cylinder at 240 rpm in sizes of 5 to 10 cylinders. 2-cycle, 21½ by 27½ in. engine operates on standard diesel oil or low-pressure gas with small amount of pilot fuel. When running on gas, pressure in main gas manifold is varied in direct proportion to engine load. Quick closing valves in each cylinder and underspeed governor eliminate usual dangers associated with gas operation. Lima-Hamilton Corp., New York.

Processing

DISK TYPE FILTER. For liquid handling. Filter elements tightened independently of cylinder cover. By-passing of unfiltered liquid prevented by positive seal between filter media and inlet and outlet channels. Also handles volatile liquids. Ertel Engineering Corp., Kingston, N. Y.

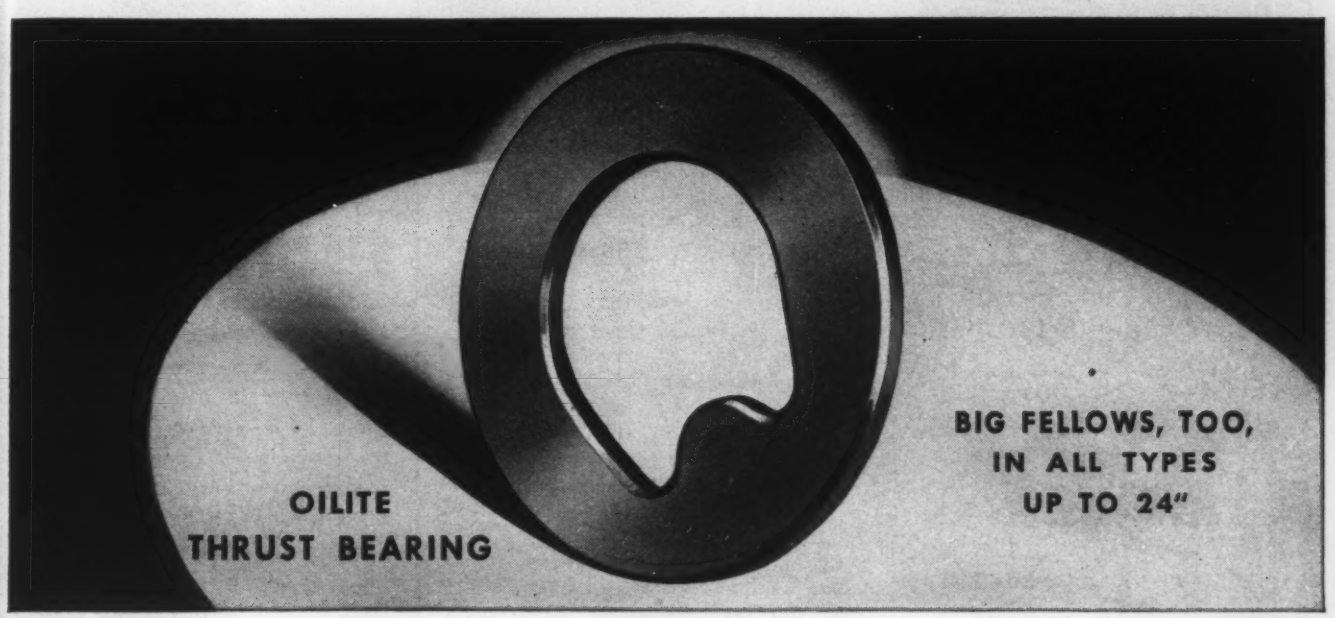
LENS WASHING MACHINES. Automatic; utilizes cleaning agent containing suspended particles which bombard lenses under pressure. As many as 60 racks of lenses can be cleaned per hour. Requires steam and electricity. Industrial Washing Machine Corp., New Brunswick, N. J.

CAN FILLING MACHINE. Handles sliced or cubed fruits or vegetables and granular products. Operates with can Nos. 2½, 2, 303, or 1 Tall at

OILITE

OIL CUSHION — HEAVY DUTY

BEARINGS



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OILITE is a precision product and permits lower bearing clearances.

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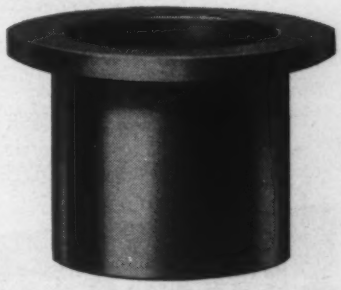
- Complete engineering service.
- Greater plant facilities.
- Over twenty (20) years of powder metal know-how.
- Representation in every state and Canada.
- Oilite bearings are not expensive.



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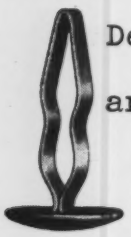

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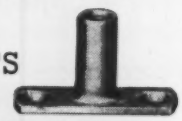

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COMBINATION OHMMETER-VOLTMETER. For testing resistances and ac or dc voltages. Indicates resistances from 0 to 2 million ohms within 2 per cent of linear scale; dc voltages from 0 to 300 volts within 2 per cent at 10,000 ohms per volt; ac voltages from 0 to 300 volts within 5 per cent at 0 to 10,000 ohms per volt. Features single, two-scale dial; weight, 12 oz less leads. International Instruments Inc., New Haven, Conn.

TEARING TESTER. For paper and paper products. Total capacity of 200 grams suitable for tissues, plastic films, and other light materials. Calibrated pendulum provides driving force to tear sample held between two pairs of jaws. Thwing-Albert Instrument Co., Philadelphia.

ABRASION TESTING SET. Uses rotary abrading action on four-inch specimen. Abrasive wheels available for testing surface finishes of electroplate, porcelain enamel, organic coatings, leather, glass, plastics, and woven textile fabrics. Speed of suction pump variable. Adjustable timer shuts off tester after test period of 1000 cycles or less. Taber Instrument Corp., New York.

BOOK TWO

PRODUCTION PROCESSES

Their Influence on Design

By

ROGER W. BOLZ

Associate Editor, Machine Design

To assist the designer in evaluating the multitude of processing methods presently available and help attain the eminent advantages of maximum economy, accuracy and speed in the manufacture of tomorrow's machines, this reprint has been made available. Comprising the second fifteen parts in this series of articles which has been appearing in MACHINE DESIGN, the volume is designated as Book II and matches in size and format the reprint of the first fifteen parts.

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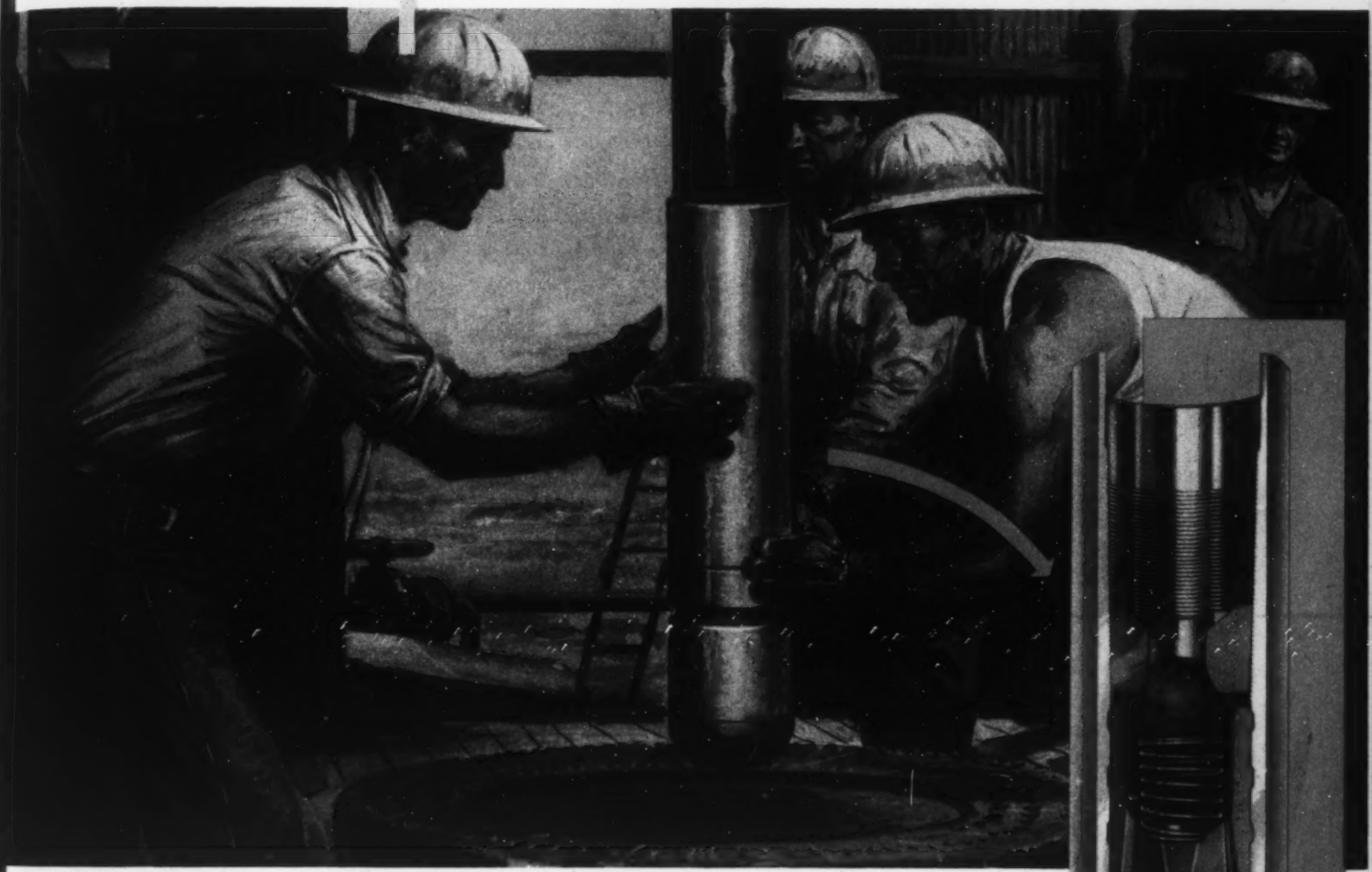
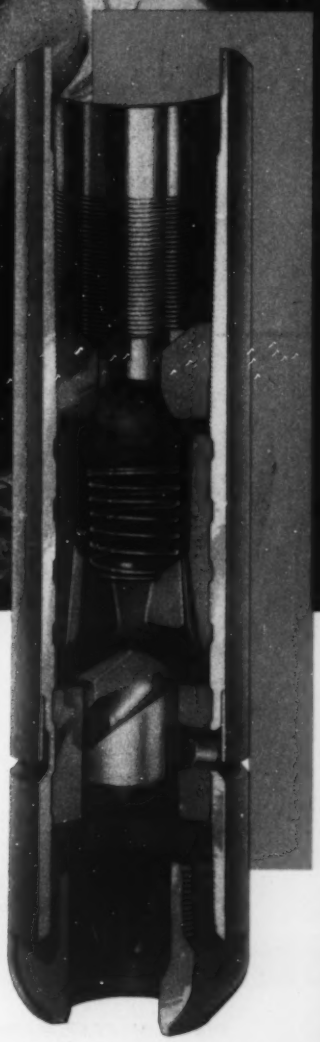
for strength, wear resistance, and ease of machining . . .

Structural strength, wear resistance, and ease of machining are three of Synthane's many properties which, in combination with its other mechanical, chemical and electrical characteristics make it one of industry's valuable materials.

A good electrical insulator, Synthane, the set plastic, is stable over a wide range of temperatures. Hard, dense and durable, it also possesses desirable moisture and corrosion-resistant qualities.

The ability of Synthane to stand up under adverse conditions is interestingly demonstrated by its use in the Turbo-Jet Float Shoe.





Various parts of Float Shoes, used in cementing oil wells, are fabricated from Synthane, for example, the valve ball and thrust plate in the shoe illustrated at the right.

Synthane resists the abrasive action of the liquid cement pumped through the shoe. It is thermosetting, so that it retains its original size and shape, yet is easily drilled out after the cement has set. Thus, Synthane's combination of strength, wear resistance, stability and ease of machining make it a perfect material for this difficult job.

If this brief review of Synthane's unique combination of desirable properties suggests its use in your product, let us help you with design, materials or fabricated parts. Write today for the new Synthane Plastics Catalog, 5 River Road, Oaks, Pennsylvania.

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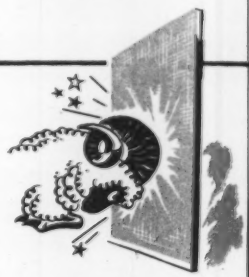
Synthane resists corrosive atmospheres, moisture, oils and solvents. Synthane is also the set plastic, stable over a wide range of temperatures.

Synthane is an excellent insulator —with high dielectric strength, low power factor and low dielectric constant. The ease with which it may be machined adds to its value for practical applications.



Hard and dense, Synthane resists fatigue under repeated impact. Withstands abrasion, does not splinter.

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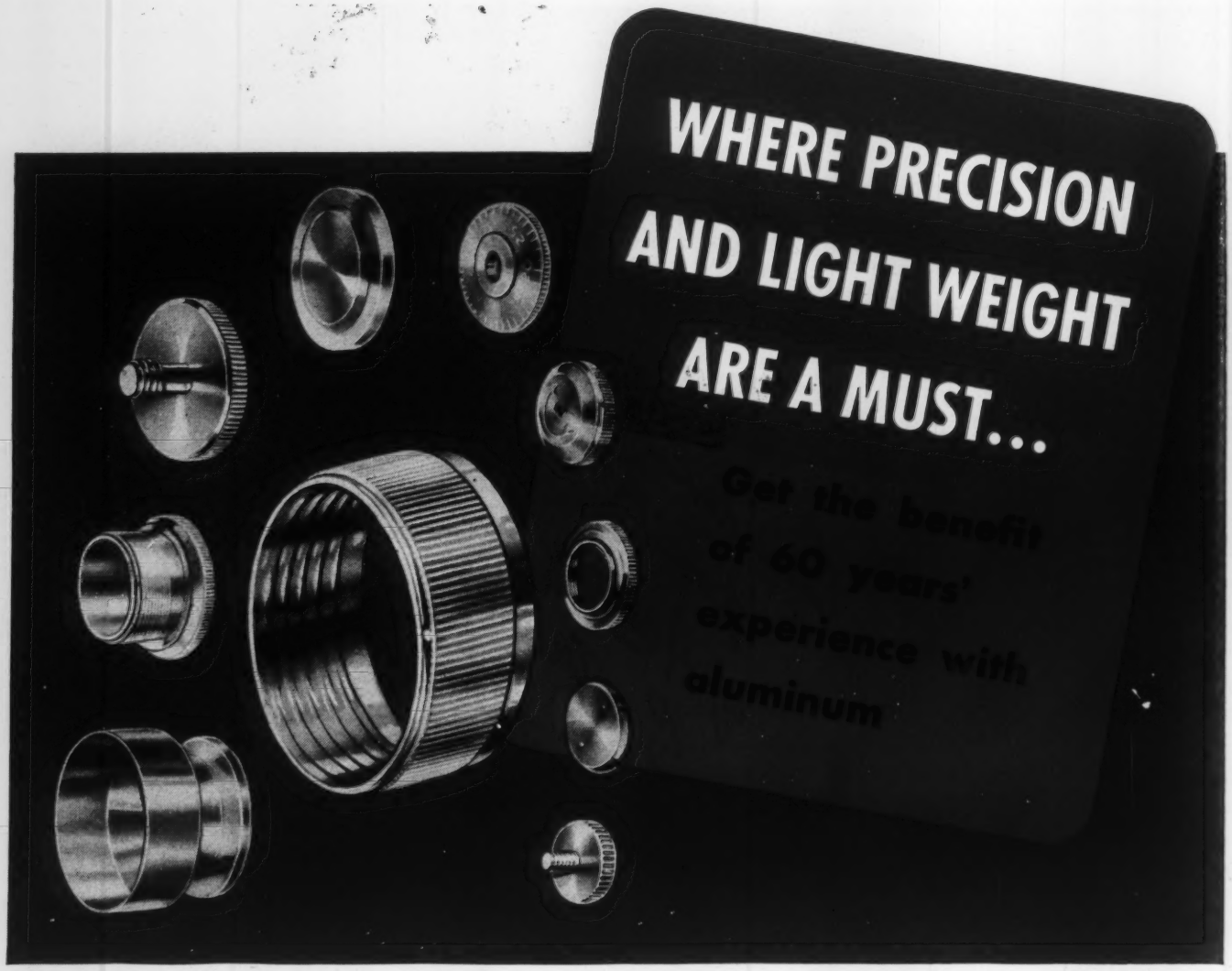

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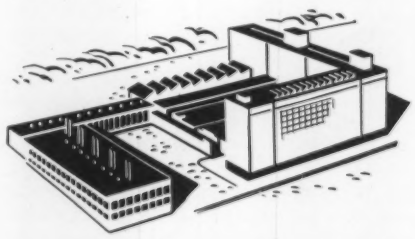

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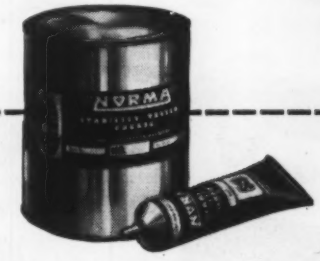

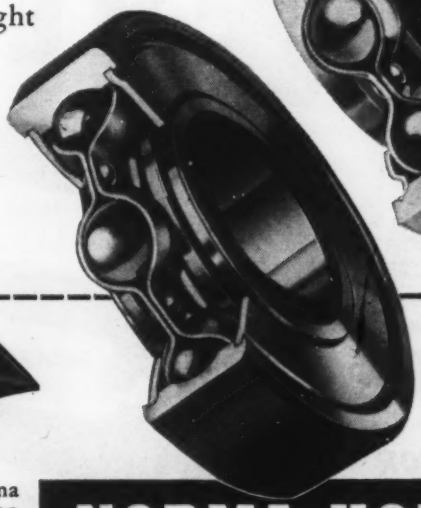

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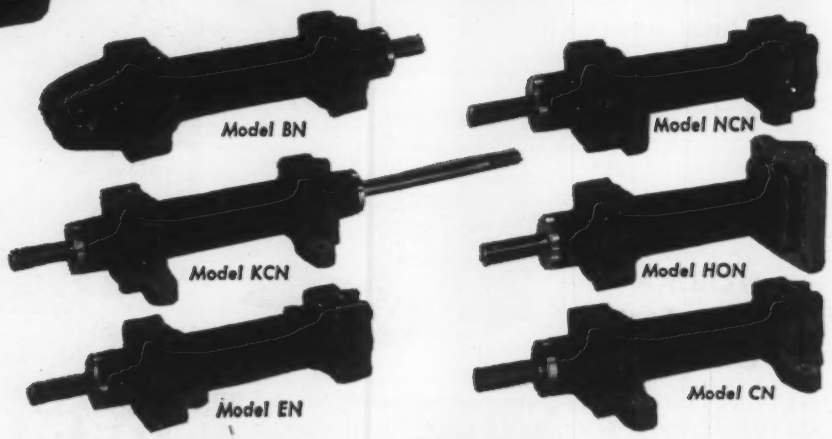

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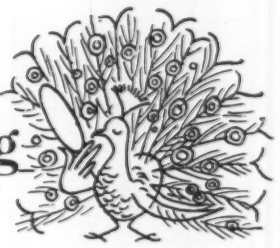

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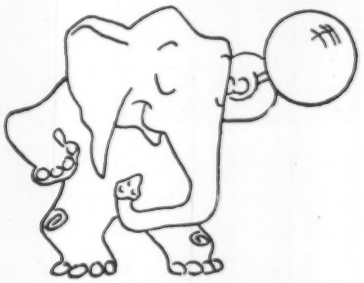

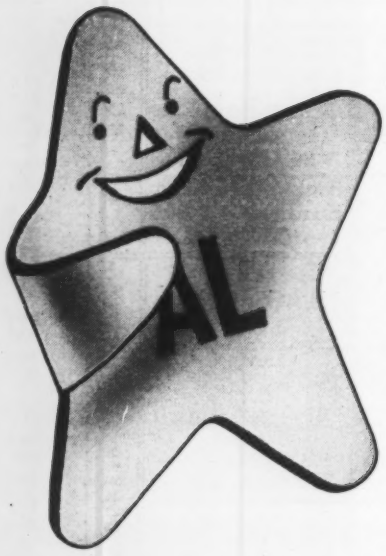

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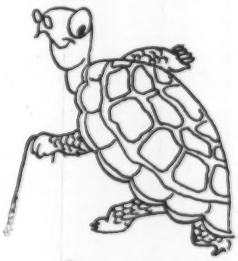

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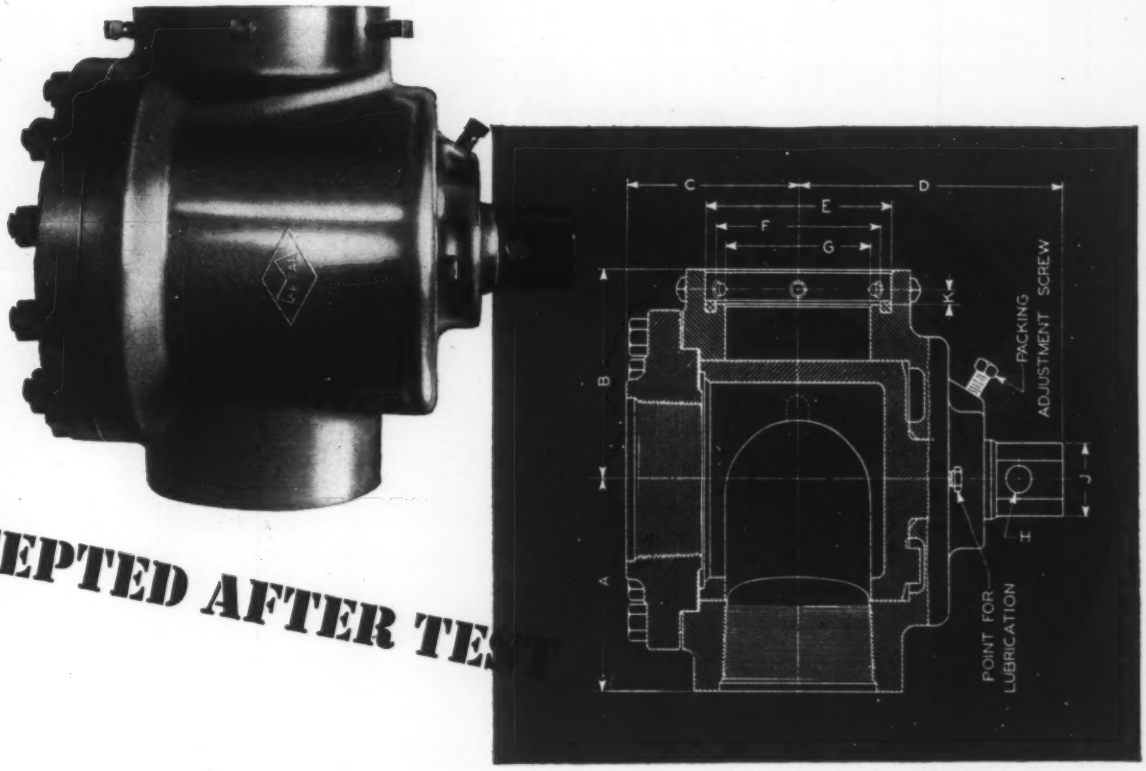

ORBIT VALVE SELECTS Meehanite® Castings

Desirous of improving the dependability and service qualities of an oil well control head, Orbit Valve Company, Tulsa, Oklahoma conducted numerous pressure and property tests. As a result of these tests Meehanite castings are now specified.

The unit is used in conjunction with cable-type drilling tools for oil and gas well drilling-in and cleaning-out operation. Its purpose is to control pressure kick-back which sometimes occurs during these operations. While not considered a high-pressure unit, each body must withstand a 2000 psi hydro-static pressure test without any signs of seepage. In addition, smooth, uniform, dimensionally accurate and machinable castings are desired.

Meehanite castings regularly meet these requirements as a result of the many rigid controls of metal, melting and foundry practice applied in their manufacture.

Write for Meehanite Bulletin No. 10 "Meehanite —the Metal for Pressure Castings."

Meehanite®

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Atlas Foundry Co.	Detroit, Michigan
Banner Iron Works	St. Louis, Missouri
Barnett Foundry & Machine Co.	Irvington, New Jersey
E. Long Ltd.	Orillia, Ontario
E. W. Bliss Co.	Hastings, Mich. and Toledo, O.
H. W. Butterworth & Sons Co.	Bethayres, Pennsylvania
Continental Gin Co.	Birmingham, Alabama
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co.	Portland, Oregon
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
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Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
The Henry Perkins Co.	Bridgewater, Massachusetts
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Kanawha Manufacturing Co.	Charleston, West Virginia
Koehring Co.	Milwaukee, Wisconsin
Lincoln Foundry Corp.	Los Angeles, California
Otis-Fensom Elevator Co., Ltd.	Hamilton, Ontario
Pehlman Foundry Co., Inc.	Buffalo, New York
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
Smith Industries, Inc.	Indianapolis, Ind.
Standard Foundry Co.	Worcester, Massachusetts
The Stearns-Roger Manufacturing Co.	Denver, Colorado
Trayior Engineering & Mfg. Co.	Allentown, Pennsylvania
U. S. Challenge Co.	Centerville, Iowa and Batavia, Illinois
Valley Iron Works, Inc.	St. Paul, Minnesota
Vulcan Foundry Co.	Oakland, California
Warren Foundry & Pipe Corporation	Phillipsburg, New Jersey

"This advertisement sponsored by foundries listed above."

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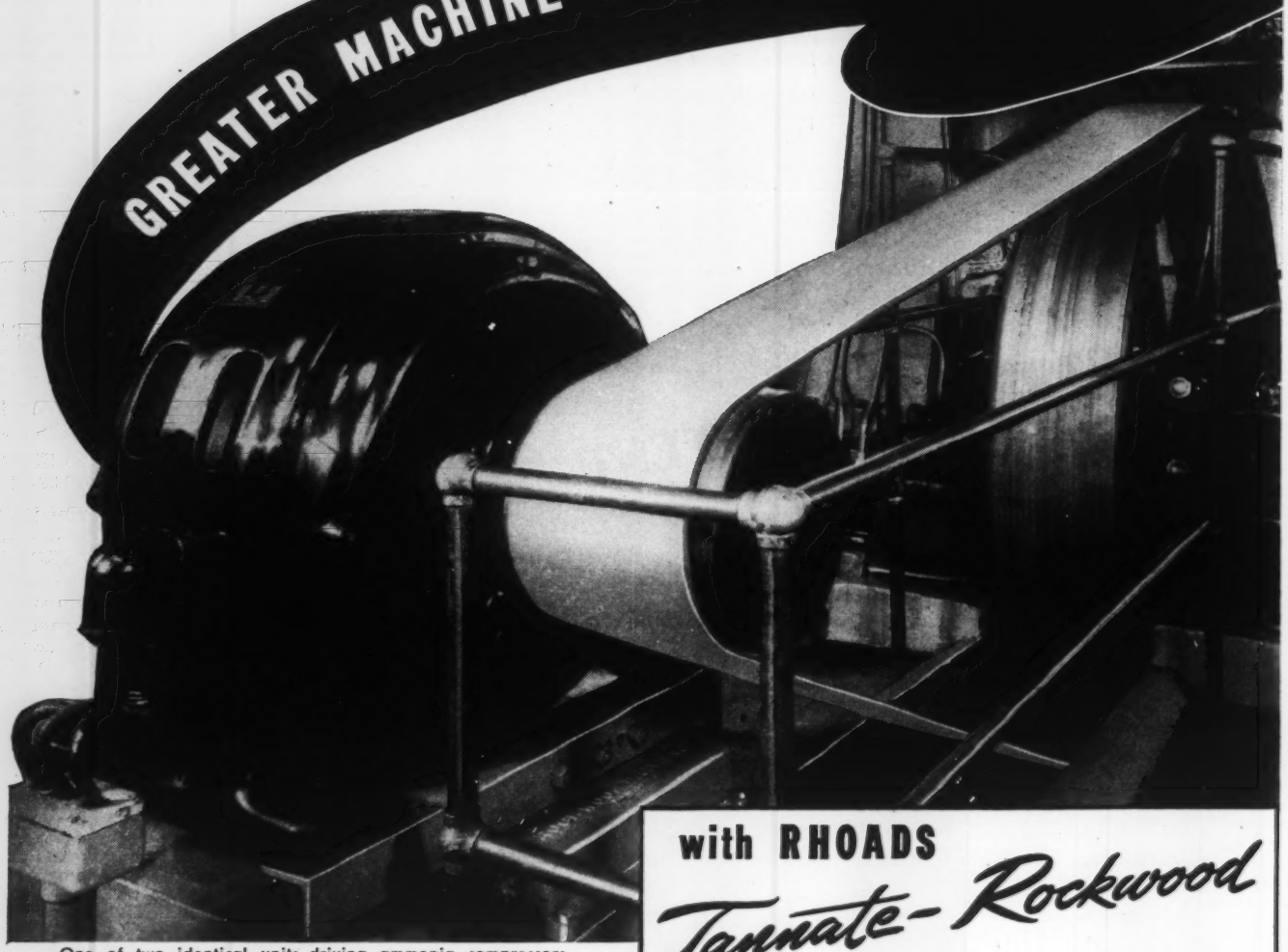
GREATER MACHINE OUTPUT AT LOWER COST



One of two identical units driving ammonia compressors, this 14" TANNATE belt has been in service more than 13 years—and is still running. Capacity of plant reported increased; power costs appreciably reduced.

with RHOADS *Tannate-Rockwood* SHORT CENTER DRIVE

TANNATE-ROCKWOOD Drives give you maximum output and full delivery of power at low cost over years of trouble-free operation. A minimum of maintenance is required.

The pivoted base assures correct belt tension for varying loads. The tough TANNATE belt carries high overloads and retains high efficiency.

Hundreds of TANNATE-ROCKWOOD drives in a great variety of applications have proven to the users that they are better than most other means of short center driving. For further information, consult our engineering department.

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faster

BRUNING BW WHITEPRINTERS

Model 21 Bruning Whiteprinter for moderate print production.

There is a Bruning Whiteprinter to meet the requirements of any drafting or engineering department . . . and every one of them is designed to make perfect prints of your tracings . . . fast.

In seconds after you turn on a Bruning machine you are producing copies that are tops in legibility. There is no time lost waiting for prints to dry . . . BW prints are ready for instant use as fast as they come from the machine. There is no time spent making negatives . . . BW machines make clear, sharp positive prints (black on white) directly from any copy that is drawn, typed or printed on a translucent material.

If you need sharp duplicate prints . . . big or small . . . on paper, card, film, or cloth, it will pay you to investigate Bruning Whiteprinters . . . the last word in efficient and accurate duplication of engineering and/or office forms.

CHECK THESE BW ADVANTAGES

Just plug in: Bruning Whiteprinters plug into standard 110 or 220 outlets, depending upon the size of the machine. No special wiring required.

No vents or exhaust fans: The BW process is completely odorless . . . can be performed anywhere in the office without the slightest offense.

No plumbing connections: There are no pipes to connect, no water to supply or drain away. Nothing to anchor the machine to one spot.

Wide variety of prints: BW prints can be made on light, medium or card weight paper with black, blue, red or brown lines. Also on tinted stocks, transparent paper, film and cloth.

A 1001 uses: A BW unit can reproduce a letter, invoice, chart, financial report or other document as easily and quickly as it makes perfect prints from engineering drawings. It is truly a company-wide machine . . . saving time and money for every department.

Send today **for full information.**

Let us send you a file of descriptive literature on Bruning Whiteprinters and BW materials. There is no obligation. It would be helpful to know approximately how many copies you plan to make a day and their average size.

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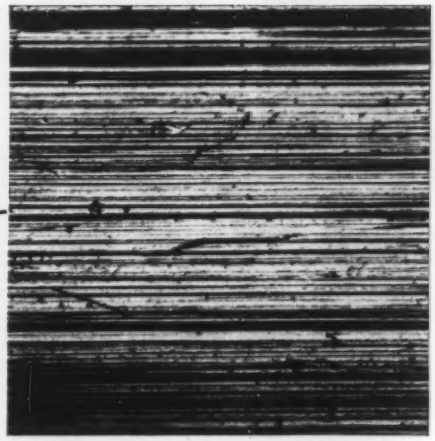
YOU CAN SEE THE DIFFERENCE

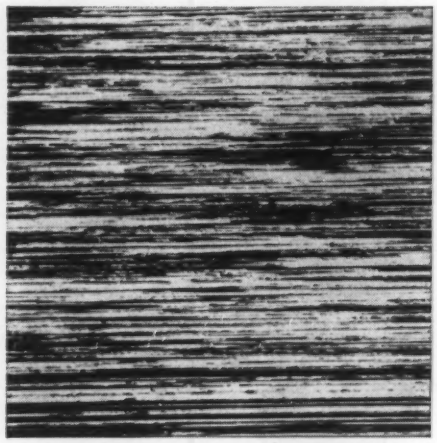
IN HOOVER HONED RACEWAYS

The photographs reproduced at the right are magnified one hundred times, so that you can see the difference between ground, polished and honed raceways. Hoover is America's only ball bearing with honed raceways. The process and the special machines for the honing operation, are exclusive, patented, Hoover developments. Hoover honing goes far beyond grinding and polishing to produce a surface that represents the closest approach to absolute perfection obtainable on a commercial basis.



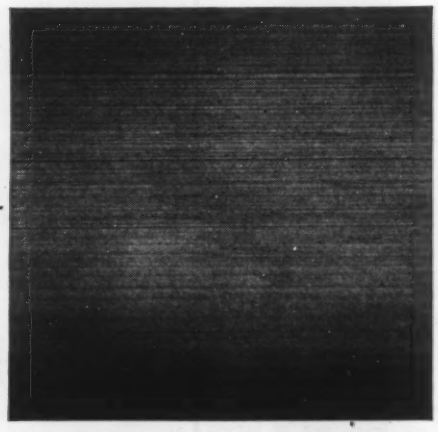
GROUND RACEWAY SURFACE
(Photographed at 100 Magnifications)

This precision ground surface is satisfactory for many types of precision products and for low-speed thrust bearings. Not suitable for high speed radial bearings demanding smoothness, quietness, long life and high load capacity.



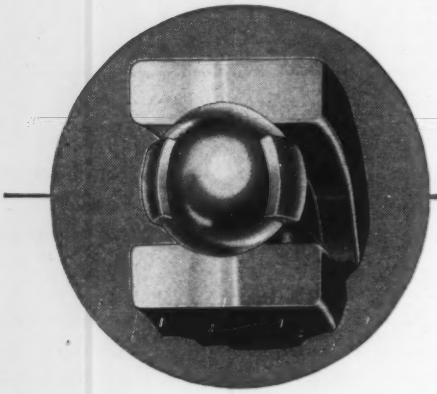
POLISHED RACEWAY SURFACE
(Photographed at 100 Magnifications)

Adding polishing operation improves on ground surface. But increased smoothness and quietness is achieved at expense of shortening bearing life and decreasing load capacity because polishing does not permit raceway radius to be held within sufficiently close precision limits to insure uniformity.



HONED RACEWAY SURFACE
(Photographed at 100 Magnifications)

Photo-micrograph illustrates how cuts and scratches resulting from grinding and polishing are reduced to practically non-existence by Hoover honing process. This patented Hoover process achieves bearings equal to super-fine laboratory specimens, at a price you can afford to pay.



Honed Raceway Features

Summed up Hoover honing provides the following results . . .

1. Extreme quietness.
2. Increased load capacity.
3. Extended life.
4. Reduced end play (axial displacement).
5. Reduced radial displacement.
6. Permanence of fit up.
7. Increased resistance to Brinneling.
8. Uniformity of fit up.
9. Freedom from vibration.
10. Perfection of dynamic balance.

THE ARISTOCRAT OF BEARINGS

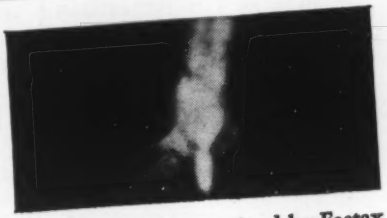
HOOVER "AMERICA'S ONLY BALL BEARING WITH HONED RACEWAYS"

HOOVER BALL AND BEARING CO., ANN ARBOR, MICHIGAN

FREE Demonstration Film shows how high-speed motion pictures can aid you in research, engineering, and testing

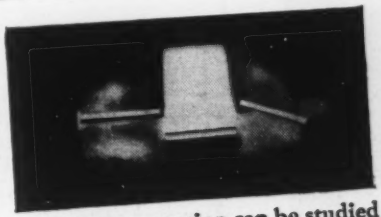
HIGH SPEED CUTTER, machining stainless steel, is photographed with Fastax to find cause of uneven cutting.

VALVE SPRING, while operating at 1500 cycles per minute in truck engine, appears to stand still on the screen.



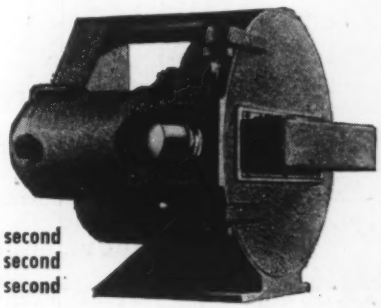
CIRCUIT BREAKER is examined by Fastax camera to determine detailed behavior of arc.

IMPACT TEST ON HARD RUBBER. Shows stress patterns and characteristics of breakage.



PUNCH PRESS operation can be studied at ease by means of Fastax motion pictures.

FASTAX CAMERA



8mm—up to 10,000 frames per second
16mm—up to 5,000 frames per second
35mm—up to 3,500 frames per second

Here's an easy way to see how the Fastax camera has helped others in their research, engineering and testing problems. In this film you'll see super-speed pictures of actual manufacturing and testing operations—plus a detailed demonstration of how the camera operates.

The world's fastest portable motion picture camera, the Fastax is capable of photographing the action of rapidly moving parts—indoors or outdoors, in black and white or color—at speeds up to 10,000 frames per second.

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Just fill in the coupon below, giving at least four weeks advance notice as to when you want the film, and we'll be glad to send it to you without obligation. All you need is a 16mm silent projector. We'll also send you complete literature on the Fastax, if you wish.

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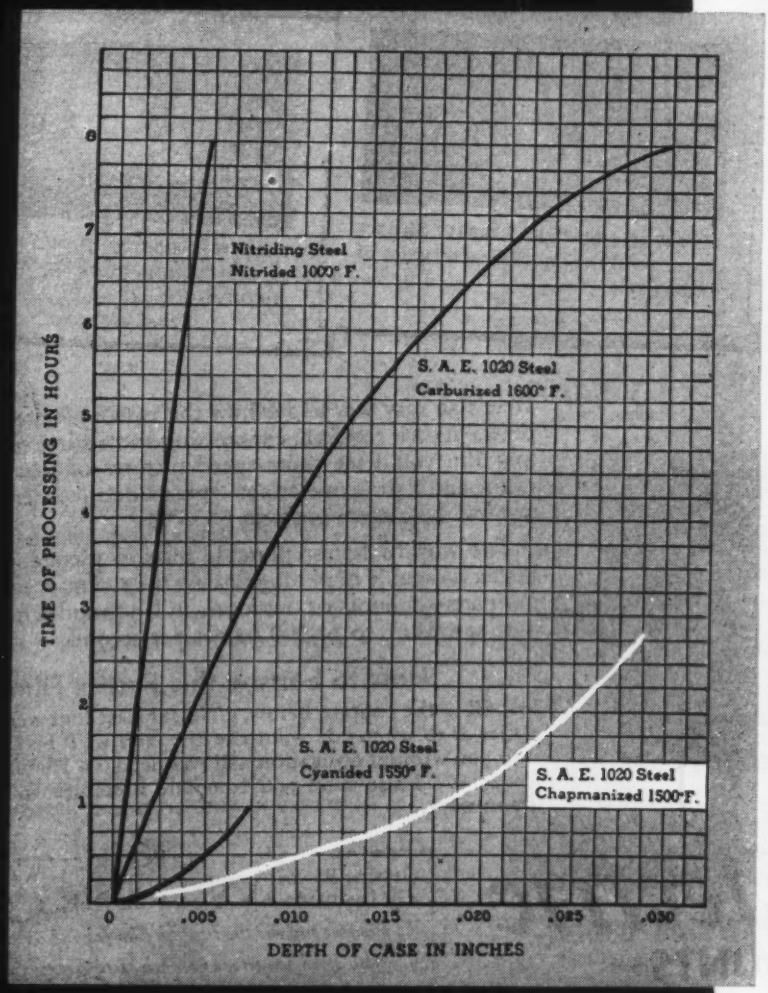
In only 1 to 4 hours Chapmanizing

Gives Free-Machining Steels Any Desired DEPTH OF CASE from .002" to .035"



So fast is Chapmanizing that any desired depth of case (from .002" to .035") can be produced on low-carbon steels in only 1 to 4 hours. And the case will be tough and ductile — free from chipping and checking. It will be silver-clean, too, requiring minimum finish grinding.

If you are interested in *faster surface-hardening* send us your parts today or let us send you the name of the nearest licensed Heat Treater. Or, if you prefer, we can hook a unit to your own pot-type furnace and you can Chapmanize right in your own plant.

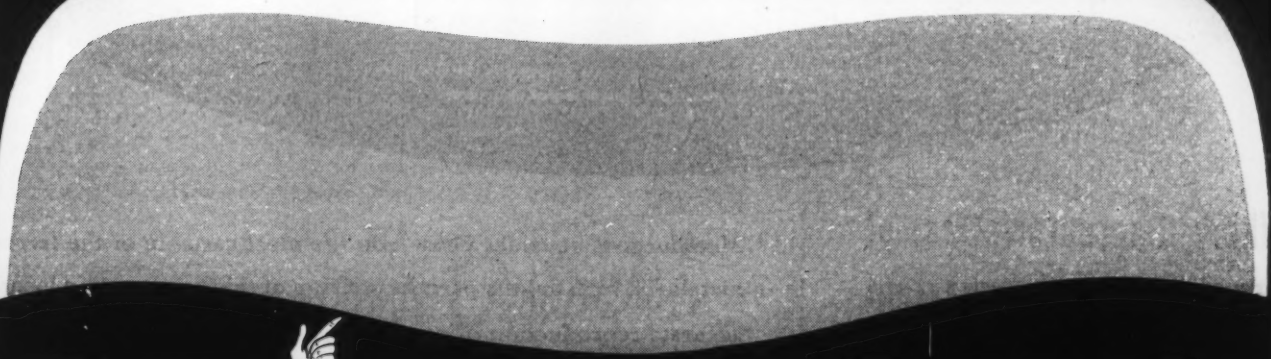
Metallurgical Sales Division of

THE CHAPMAN VALVE MFG. CO.

INDIAN ORCHARD, MASSACHUSETTS

The New General Plate Laminated Silver on Aluminum Button

SILVER DOME Provides High Electrical Conductivity

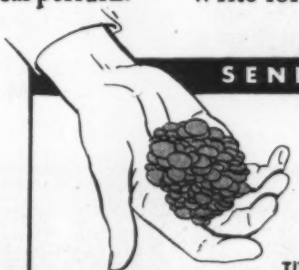


ALUMINUM BASE Reduces Weight, Has Greater Heat Dissipation, Reduces Bouncing

Again General Plate pioneers in laminated metals . . . this time it is the new *Silver on Aluminum* Button...especially suited for heavy-duty contacts or large contacts. The silver surface gives better electrical performance. The aluminum makes the contact lighter-in-weight, permits larger contacts because it has high heat dissipation characteristics.

General Plate *Silver on Aluminum Buttons* reduce costs, too, because they replace expensive solid silver contacts. Moreover, all requirements can be met with these money-saving contacts. They are available in practically all regular laminated button shapes. Write for information and samples.

GENERAL PLATE DIVISION
of Metals and Controls Corporation
201 Forest Street, Attleboro, Mass.



SEND FOR SAMPLES TODAY

GENERAL PLATE DIVISION
of Metals and Controls Corporation
201 FOREST STREET, ATTLEBORO, MASS.

Gentlemen: Please send me complete information and samples of Silver on Aluminum Buttons.

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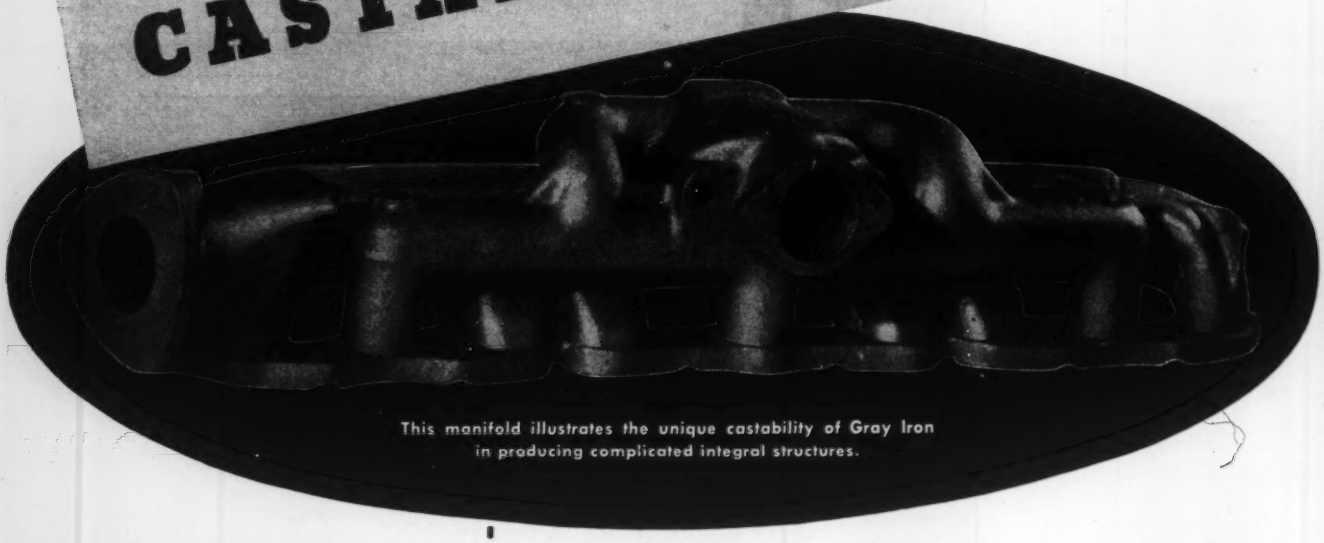
1-149

. . . Are you taking full advantage of Gray Iron's CASTABILITY?



This manifold illustrates the unique castability of Gray Iron in producing complicated integral structures.

Which Characteristics of Gray Iron are Important for Your Product?

CASTABILITY

Rigidity

Low Notch Sensitivity

Wear Resistance

Heat Resistance

Corrosion Resistance

Durability

Vibration Absorption

Machinability

Wide Strength Range

Metallurgists consider Gray Iron the most castable of the ferrous metals. Its high fluidity permits pouring of thin sections and insures accurate reproduction of complicated designs.

The advantage of thus being able to produce an intricate structure in one integral piece is obvious. You avoid the necessity of assembling separate parts, also the machining and fitting of joints.

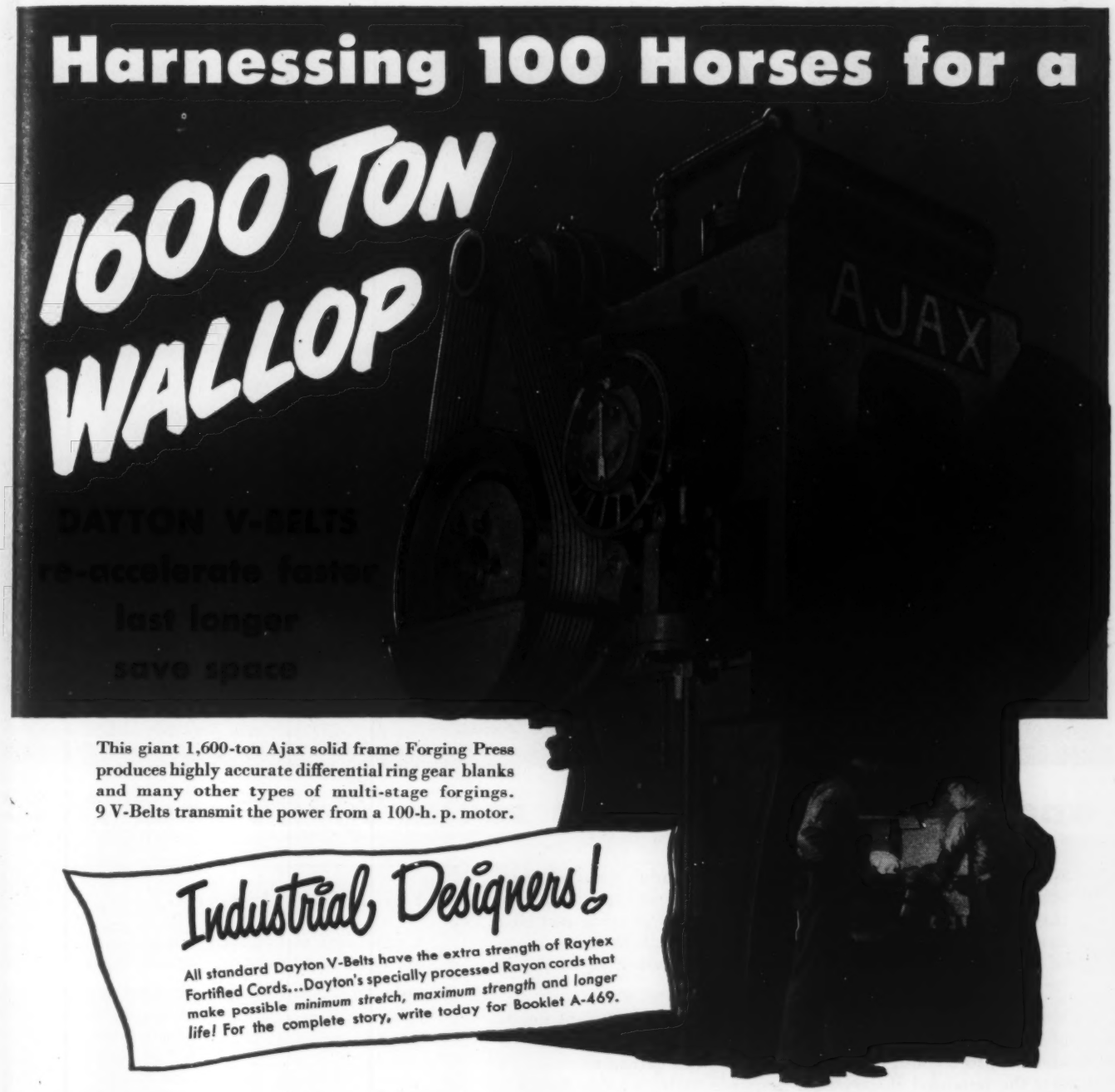
Every gray iron component you use offers not just one but a combination of important properties not obtainable in other materials . . . *plus ultimate economy.* That is why gray iron is so widely used, so difficult to replace with satisfactory substitutes. Send for free booklet, "GRAY IRON—Its Mechanical and Engineering Characteristics and Details for Designing Cast Components."

Make It Better With Gray Iron

GRAY IRON FOUNDERS' SOCIETY, INC.

NATIONAL CITY BANK BLDG., CLEVELAND 14, OHIO

Harnessing 100 Horses for a 1600 TON WALLOP



This giant 1,600-ton Ajax solid frame Forging Press produces highly accurate differential ring gear blanks and many other types of multi-stage forgings. 9 V-Belts transmit the power from a 100-h. p. motor.

Industrial Designers!

All standard Dayton V-Belts have the extra strength of Raytex Fortified Cords...Dayton's specially processed Rayon cords that make possible *minimum stretch, maximum strength* and *longer life!* For the complete story, write today for Booklet A-469.

Transmitting the power from a 100-h. p. motor to the flywheel of this forging press is a perfect example of the superiority of Dayton V-Belt Drives. Here, maximum drive efficiency, rapid re-acceleration after flywheel slowdown, continuous operation and compactness of the drive are advantages the designer desires.

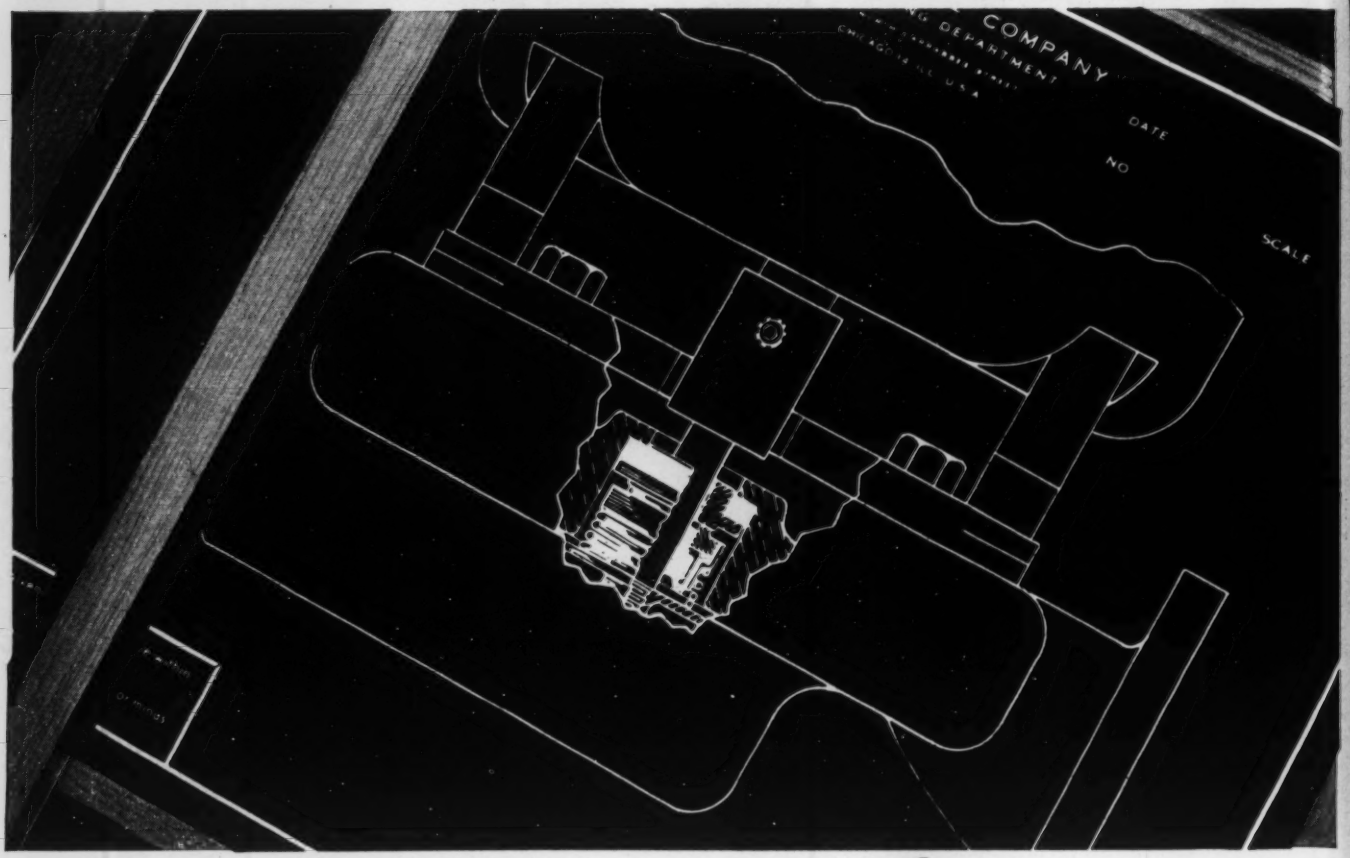
And he gains them all with Dayton V-Belt Drives. First, Dayton V-Belts are the most efficient method of transmitting power known. They withstand the stresses and strain of sudden starts, stops and shock loads. They transmit full power, fast. They flex around the pulley easily, without heating. And they save space by permitting the use of shorter centers, smaller pulleys.

Made with super-strength Raytex Fortified Cords, Dayton V-Belts offer minimum stretch, maximum strength, longer life. They are unaffected by oil, heat or abrasive conditions. No matter what your power transmission problem, there is a Dayton V-Belt Drive that will solve it perfectly. Dayton Power Transmission Specialists stand ready to help you at any time. Write or phone *The Dayton Rubber Company, Dayton 1, Ohio, today.*

Dayton Rubber

THE MARK OF TECHNICAL EXCELLENCE IN NATURAL AND SYNTHETIC RUBBER

THIS BUILT CERTAINTY INTO A CIRCULATOR—



and ROTARY SEAL can make *Your* seal *sure*

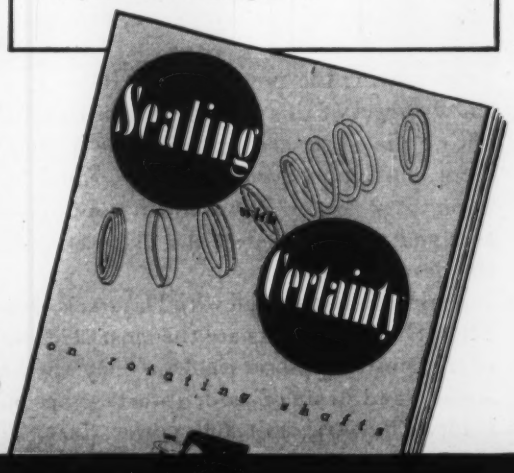
A "booster" just won't boost properly without a sound shaft seal—one that removes *all* uncertainty from performance throughout the life of the unit. Rotary Seals provide just that assurance, not only for circulators but for all the many types of equipment with which positive shaft-sealing is of prime importance.

You see, Rotary Seals are "tailor-made" to fit the specific needs of each application. You don't have to juggle a stock part or assembly to try and make it fit; expert engineering assures you that the patented Rotary Seal principle will be provided in a form which exactly meets your requirements. That way, you're sure of maximum efficiency, reduction of maintenance and repair expense, and trouble-free performance in actual use.

We believe Rotary Seal engineers can save *you* time and money, too—call them in on the first steps of your project!

THE ROTARY SEAL PRINCIPLE

is explained and illustrated in detail in our booklet, "Sealing with Certainty on Rotating Shafts". You should have this information—we'll be glad to send it to you without obligation.



THE ROTARY SEAL COMPANY
mechanical seals for rotating shafts

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HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

68. Welded Design
Lincoln Electric Co.—Illustrated data sheet No. 101 deals with the design of levers for weld fabrication. Various elements of levers such as hub linkage connection and other sections are discussed.

69. Small Motors
F. A. Smith Mfg. Co.—12-page illustrated bulletin No. 448 presents information relative to line of two and four-pole fractional horsepower motors. Performance data are charted and construction features covered.

70. Alloy Steel Screws
Strong, Carlisle & Hammond Co.—6-page illustrated vest-pocket size folder No. 43-A describes line of hollow set screws, socket head screws, hexagon socket pipe plugs, square head screws, slotted headless screws, cap screws, hollow lock screws and other products in Mac-it line.

71. Rubber Products
Stalwart Rubber Co.—Illustrated catalog describes wide range of custom fabricated rubber products. Photos and discussions cover molded, extruded, lathe-cut and punched shapes. Products are available in natural and various synthetic rubbers.

72. Automotive Parts
Eaton Mfg. Co.—42-page vest pocket size catalog describes current principal products for industrial and automotive markets. Fifteen expanded plants and their manufacturing facilities are covered.

73. Air Filters
Dollinger Corp.—8-page illustrated bulletin SIF describes complete line of Staynew dry-type intake air filter for all types of air compressors, diesel and gas engines, blowers, motors and generators.

74. Flexible Couplings
Thomas Flexible Coupling Co.—6-page illustrated vest-pocket size folder presents information on flexible couplings for application involving every speed and horsepower.

75. Machining Data
Meehanite Metal Corp.—20-page illustrated booklet "How to Machine Meehanite Castings" outlines methods of machining various types of Meehanite castings. Booklet is divided according to type of machine tool used; and it gives exact feeds, speeds, depths of cut, type of tool, etc.

76. Hydraulic Controls
Blackhawk Mfg. Co. — 4-page illustrated folder No. 4C/1a deals with line of pumps, rams, valves and accessory units for hydraulic control. Specifications for this high pressure equipment are included.

77. Special Purpose Motors
Howell Electric Motors Co.—6-page illustrated bulletin No. DG-2 presents detailed description of protected open type, splashproof and sanitary totally-enclosed nonventilated type motors for use in dairy, food and allied industries.

78. Gear Testing
Gleason Works—12-page illustrated form No. SD-802-A provides information on machines designed to determine accuracy of all types of gears during all stages of manufacture.

79. Reproduction Machine
Charles Bruning Co.—4-page illustrated bulletin No. A-1050 explains features of new model 21 Bruning Whiteprinter which produces duplicate copies of anything drawn, written, typed or printed. Sharp, clean copies are produced in matter of seconds in sizes up to 42 inches wide and in any length.

80. Clutch Facings & Materials
Raybestos-Manhattan, Inc. — 8-page illustrated bulletin No. 200 provides information on R/M line of clutch facings and materials. Twelve popular types are illustrated, and 22 types are described.

81. Wire Cloth
Ludlow-Saylor Wire Co.—80-page illustrated spiral-bound booklet "Industrial Wire Cloth and Woven Wire Screens" describes products fabricated from Super-Loy, steel, galvanized steel, stainless, Monel, nickel, aluminum, phosphor bronze or other metal or alloy. Products are available to meet any requirements.

82. Couplings & Valves
Roylyn, Inc.—20-page illustrated catalog No. R-100 contains engineering data and specifications on quick couplings, caps, coupling-valves and related products.

83. Cemented Carbide Tools
Jessop Steel Co.—24-page illustrated catalog describes tools, dies and other wear resisting parts made from Malta cemented carbide and T and V cast nonferrous alloy. Specifications are given for standard tool tips and wire drawing dies.

84. Forgings
Steel Improvement & Forge Co.—44-page illustrated booklet "The Improvement of Metals by Forging" covers characteristics of forgings, and discusses considerations in designing for use of forgings.

85. Fastening Device
B. F. Goodrich Co.—28-page illustrated revised Rivnut data book describes new power and manual tools for use with these fastening devices. Rivnut is blind fastener which can be used either as rivet or nut plate.

86. Steel Analyses
Globe Steel Tubes Co.—Folding broadside No. 301 is corrosion and heat resisting steel analysis chart. Publication identifies steel by name of manufacturer, type number and composition. Stock sizes are tabulated.

87. Roller Chain
Atlas Chain & Mfg. Co.—8-page illustrated catalog lists prices and specifications for single and multiple roller chains ranging in size from No. 25 to No. 200.

88. Switches
First Industrial Corp., Micro Switch Div.—12-page illustrated pocket-size bulletin No. 50 covers line of diecast enclosed switches which are explosion and splashproof, type LN limit switches and other basic switches available.

89. Bearings & Bushings
Cleveland Graphite Bronze Co.—12-page illustrated catalog gives specification data on both thick and thin bushings, thrust bearings, heavy-wall bearings, main and connecting rod thinwall bearings, aircraft engine bearings, and camshaft bearings.

90. Small Electric Motors
Emerson Electric Mfg. Co.—4-page illustrated form No. B580, Unit X6050, covers line of fractional horsepower motors. Charted data reveal torque, starting current and maximum load-rotor current.

91. Molding Powder
Rohm & Haas Co., Plastics Dept.—12-page illustrated booklet No. 5648 is descriptive of Plexene M modified polystyrene powder for injection molding. Properties of this new powder are covered in detail.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below.

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92. Fatigue Testing Units

Baldwin Locomotive Works—8-page cartoon illustrated bulletin No. 291 utilizes sketches to emphasize importance of knowing dynamic and cyclic stresses on machine parts and structural members.

93. Electric Motors

B. A. Wesche Electric Co.—8-page illustrated catalog No. 3a/17 is descriptive of custom-built Welco torque motors which can be furnished in any size for any application.

94. Gasoline Engines

Allis-Chalmers Mfg. Co., Tractor Div.—8-page illustrated publication MS-421 describes operating characteristics and specifications of model B125 gasoline engine power unit.

95. Low-Heat Welding

Eutectic Welding Alloys Corp.—8-page illustrated bulletin Vol. 5 No. 5 presents advantages and features of low-heat welding alloys. Complete case histories of eight difficult welding problems are covered.

96. Phosphor Bronze Materials

Phosphor Bronze Corp.—28-page illustrated technical data book "Elephant Brand Phosphor Bronze" provides tabular data covering strip and sheet, wire, rod, rope, castings, bushings and ingots.

97. Small Relays

Struthers-Dunn, Inc.—Bulletin No. 2100 contains information on line of Midget industrial control relays. Exact contact arrangement, mounting details and physical and electrical features of each unit are included.

98. Induction Motors

Electric Machinery Mfg. Co.—8-page illustrated catalog No. 1300-PRD-189 describes heavy-duty squirrel-cage induction motors. Publication shows details of construction. These four-pole units are rated 100 horsepower and larger.

99. Binding Post

Superior Electric Co.—4-page illustrated folder No. 8481 outlines five uses for which binding posts can be adapted such as permanent clamping, spade lug connection, plug-in for banana plugs, looping and clamping, and clip lead. They have 30 ampere current capacity and 1000-volt working voltage.

100. Appliance Finishes

Sherwin-Williams Co. — 16-page illustrated booklet B-657-D is descriptive of KEM appliance finishing systems which have been designed to speed finishing operations. General information and technical data are included for both baking and air-dry finishes.

101. Centrifugal Switches

Euclid Electric Mfg. Co.—Illustrated bulletin covers applications of centrifugal switches as safety over-speed and under-speed switches, as production zero-speed plugging switches and as interlocking conveyor switches.

102. Flexible Metal Hose

Pennsylvania Flexible Metallic Tubing Co. —12-page illustrated bulletin No. 52-9 describes Penflex interlocked galvanized steel hose for handling oil, grease, tar, paint, etc.; and bronze hose for handling water, steam and others.

103. Single-Control Valves

Cochrane Corp.—8-page illustrated catalog No. 4460 describes Hydromatic single-control valves, now standard equipment on Cochrane Zeolite softeners and pressure filters. Power for valve operation is provided by raw water and units are pilot actuated.

104. Aircraft Actuators

Western Gear Works—36-page illustrated catalog No. 4811 contains specific data on rotary, linear and cable-drum types of actuators. Dimensions, performance charts and specifications are presented on more than fifteen typical actuators.

105. Industrial Lubrication

Stewart-Warner Corp., Alemite Div.—48-page illustrated catalog No. 22-150 presents data on full line of industrial lubrication equipment. "Barrel-to-bearing" selection guide enables designers to select correct lubricants and equipment for specific applications. Guns, fittings, pumps and complete lubrication systems are some of equipment described.

106. Cold Finished Steel

Jones & Laughlin Steel Corp.—12-page illustrated technical booklet "You Can Make Them Better with Cold-Finished Jalcase" contains information on physical properties of Jalcase free-machining open hearth steel.

107. Electric Motors

Reliance Electric & Engineering Co.—4-page illustrated bulletin No. 703 is devoted to information on alternating current motors rated from ½ to 200 horsepower. Units are constant speed type AA and multi-speed type AM for two and three-phase circuits.

108. Projection Papers

Eastman Kodak Co. — 8-page illustrated booklet describes Kodagraph projection papers for use with enlargers, projection printers or process cameras. Papers are designed to provide high quality prints from microfilm negatives or engineering drawings.

109. Petroleum Products

E. F. Houghton & Co.—6-page publication No. 2-363 lists such products as lubricants, metal working and textile processing compounds, leather oils and greases, and hydraulic transmission products.

110. Electrical Cable

United States Rubber Co.—20-page catalog deals with line of latex insulated building wires and cables. In addition, performance characteristics of armored cables, service entrance cables, etc. are given.

111. Relays

Signal Engineering & Mfg. Co.—4-page illustrated folder No. 50-83 gives information relative to sensitive multiple-arm relays developed for use in wide range of industrial control circuits. Coil windings are rated from 6 to 230 volts.

112. Resin Coatings

Nukem Products Corp. — 4-page folder "Nukemite" describes this acid and alkali resistant resin coating, lists features and properties and makes recommendations as to use in steel, wire and plating plants; distilleries; and petroleum plants.

113. Pressure Control Systems

Automatic Temperature Control Co.—8-page illustrated catalog No. R-10 contains detailed engineering and application data on Atcotran systems which feature electrical transmission of pressure measurements to indicator or recorder type instruments. Accuracy is to within 0.25-per cent.

114. Small Motor

Alliance Mfg. Co.—Illustrated data sheet is devoted to model K Phonomotor designed for 25-cycle operation on either 117 or 234-volt current. Unit is furnished complete with turntable.

115. Lubricated Plug Valves

H. K. Porter Co.—16-page illustrated catalog No. 48-V deals with line of lubricated plug valves in pipe sizes from 1 to 12 inches. Semisteel valves can be furnished for working pressures of 175, 300 and 500 pounds per square inch and stainless steel valves for working pressures of 150 and 300 pounds per square inch.

116. Magnetic Separators

Eriez Mfg. Co.—8-page illustrated catalog No. 12 is devoted to descriptive material on line of permanent nonelectric magnetic separators. Specification regarding weights, sizes and strength comparisons for various types of plate magnets are given. Tables of operating capacities for pulleys, drums, etc. are included.

117. Induction Heating

Ohio Crankshaft Co., Tocco Div.—48-page illustrated booklet on induction heating reveals actual case histories of hardening, forging, brazing and annealing jobs.

118. Fixed Volume Pumps

Rockwell Mfg. Co., Hydraulics Div.—4-page illustrated folder No. 100 deals with Rotocycle Pumps having fixed volume. Units are double-acting, hydraulically and dynamically balanced, and specifically designed for high speed, high volume and high pressure applications.

119. Bronze Parts

American Crucible Products Co.—8-page illustrated vest-pocket size folder "Promet Bronze Parts" describes line of bearings, seals and wearing parts completely engineered to individual specifications. Production facilities are shown.

120. Stainless Steel

Allegheny Ludlum Steel Corp.—36-page illustrated brochure "Allegheny Metal in the Petroleum Industry" reveals information about role played by stainless steel in this industry and makes forecast of future applications in various phases of production and processing.

M. D. Numbers					
1	21	41	61	81	101
2	22	42	62	82	102
3	23	43	63	83	103
4	24	44	64	84	104
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18	38	58	78	98	118
19	39	59	79	99	119
20	40	60	80	100	120

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Everything else being equal, you can build a better carburetor for hard usage if you have more than imagination to go by. Zenith *knows* the problems! Over a forty year span, Zenith* has put more heavy-duty carburetors on trucks, tractors, bulldozers and other hard-working equipment than any other manufacturer.

That's why, in presenting the new Series 10 "Workhorse" carburetor for low horsepower engines, Zenith is absolutely certain of its durability and performance. Its high angularity design makes it function equally well on level or hillside operation, and its simplicity eliminates many mounting problems.

Designers and manufacturers are invited to draw on the specialized carburetion experience that Zenith has acquired over the years. Get full information on the "Workhorse" now by writing the factory direct. *REG. U.S. PAT. OFF.

ZENITH CARBURETOR DIVISION of Bendix AVIATION CORPORATION

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high ratios ?

ONE OF 93

DE LAVAL
DOUBLE REDUCTION WORM GEARS

De Laval double reduction speed reducers, consisting of combinations of double worm gear reductions, or helical and worm gear reductions, are available with overall ratios up to approximately 8000 to 1. De Laval single reduction worm gear speed reducers are available in ratios up to 90 to 1. If high ratios are your requirement, worm gear speed reducers are the answer—particularly if space is limited and reliability is important. A De Laval representative will help you pick the right size and type.

This double reduction De Laval Worm Gear Speed Reducer is available in many standard ratio combinations, with horizontal or vertical output shafts and is but one of 93 sizes and types of standard De Laval Worm Gear Speed Reducers.

WG-14

DE LAVAL

Worm Gear Division: De Laval Steam Turbine Co., Trenton 2, N. J.

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You will find complete data on the lamps used in pilot lights.

And illustrations — all full size — of hundreds of items you will use.

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More than 2,000 Underwriters' Listed Assemblies.

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Reduce starting current demand. Provide positive protection against motor damage, blown fuses, and resulting fire hazards due to extreme "low voltage" conditions. Ask for catalog.

Start gasoline engines easily even in cold weather. A Mercury Clutch permits the engine to come to full speed before the load is applied. It allows no-load idling and prevents stalling. Write for information.

Mercury Clutch Division

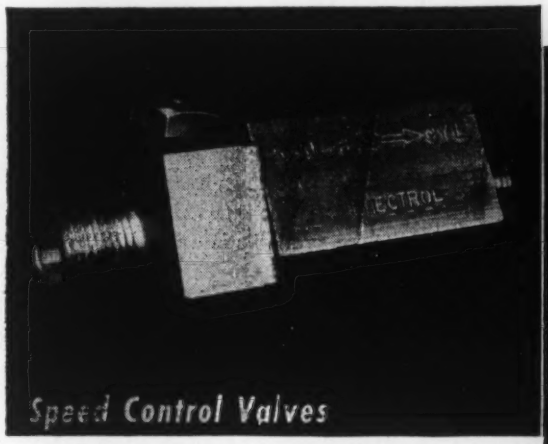
AUTOMATIC STEEL PRODUCTS, INC.
CANTON 6, OHIO

Electrol Hydraulic Devices

—in Stock or Made to Order—

FOR EVERY INDUSTRIAL NEED

Pictured here are but a few of the many hydraulic devices produced by Electrol for industry . . . transportation . . . and agriculture. We will gladly supply further details as to the application of these units in the machines you use or the products you make. Or—better still—have our engineers work with you in adapting them to any specific design.

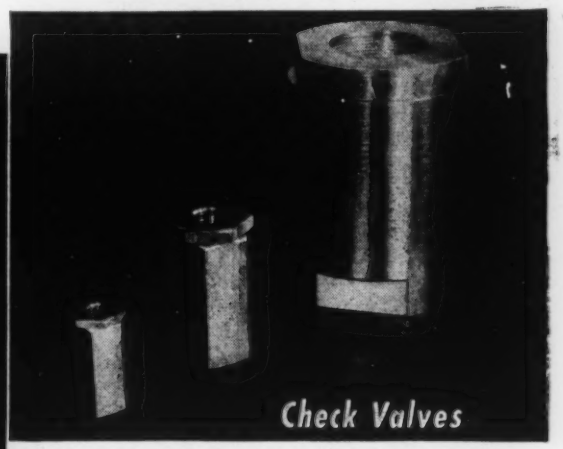


Speed Control Valves

Allow flow in one direction and, by use of a metering device, accurately control reverse flow from 0 to valve max.—even after thousands of cycles. Flow controlled by screw-actuated metering pin. Handle air or oil, with pressures up to 1,500 p. s. i. Standard sizes: ⅛, ¼, ⅜, ½ and ¾" N. P. T.

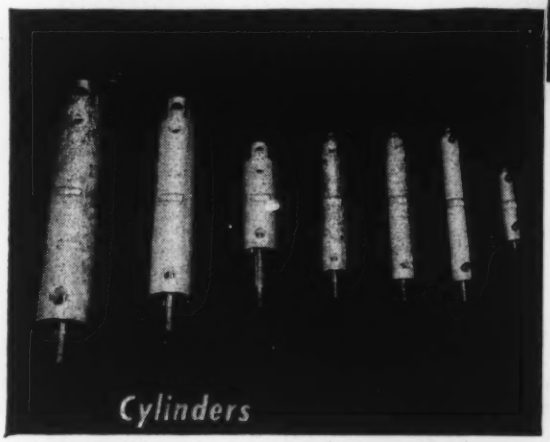
Hand Pumps

Uniform two-way action for maximum operating efficiency. Low in cost, economical in operation. Few moving parts, minimum of maintenance. Operating pressure: 0 to 1,500 p. s. i. Pump delivery: 1.5 cubic inches per cycle. ⅜" N. P. T. ports. Suction and pressure check valves built in.



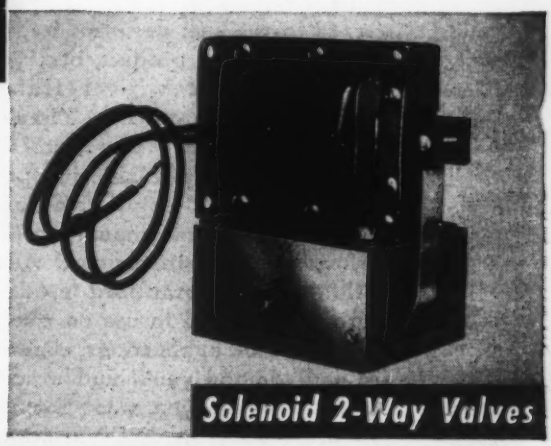
Check Valves

Provide positive sealing from low to high pressures—5,000 p. s. i. max. Used for air, gas, water and oil control with min. pressure drop and positive sealing against return flow. Standard models feature bronze and brass elements. Standard sizes: ⅛ to 2" N. P. T.



Cylinders

"500-1 Series" hydraulic cylinders available in bore diameters ranging from ¾" up to and including 3". Chromium plated piston rods, honed seamless steel tubing cylinders. Conventional "O" ring packings. Clevis mounting and standard pipe ports. Can be used in air or oil. Pressures up to 1,500 p. s. i.



Solenoid 2-Way Valves

Continuous duty, 110-volt, 60-cycle AC Solenoid 2-Way Valves with operating pressures from 0 to 3,000 p. s. i. Port sizes: ⅛, ¼, ⅜ and ½" N. P. T. Supplied either normally open or closed. Balanced type poppet and seat assures positive operation with no internal or external leakage. Other 2-Way Valves available with 12 and 24-volt DC Solenoids. Also, 4-Way Solenoid Valves with open or closed center (DC, Intermittent Duty).

Electrol

INCORPORATED

KINGSTON, NEW YORK

CYLINDERS • SELECTOR VALVES • FOLLOW-UP VALVES
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POWERPAKS • LANDING GEAR OLEOS • SOLENOID
VALVES • ON-OFF VALVES • SERVO CYLINDERS • TRANSFER
VALVES • CUT-OUT VALVES • SPEED CONTROL VALVES

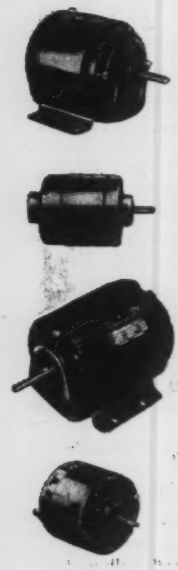
FOR BETTER HYDRAULIC DEVICES

HERE'S
LOW COST
LOW-RANGE
POWER!

Redmond MICROMOTORS

OVER 100 STANDARD MODELS

A.C. up to 1/15 Horsepower—D.C. up to 1/20 Horsepower



If small motors can make a big difference in the life, performance, or efficiency of your product, best you get acquainted with reliable Redmond Micromotors. They're sturdy little low-range power units... smooth, quiet, dependable in operation... designed, engineered, and built to give you maximum long-life performance at minimum cost. And, with over 100 standard models thoroughly proved in use on countless diversified applications, chances are at Redmond you'll find exactly the Micromotor you want for the job you want it to do. Variations from standard also available to meet special requirements. New Catalog, just off the press, covers both A. C. and D. C. lines plus blowers and speed controllers... want a copy?

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EXPANDED FACILITIES • PROMPT DELIVERIES • SERVICE BEFORE AND BEYOND THE SALE

SURE CURE FOR PUMP HEADACHES

Forget pump worries. Tuthill small pumps are recognized the world over for their dependability in lubrication, coolant, hydraulic and liquid transfer service. These internal-gear type rotary pumps are available in capacities up to 200 g.p.m. and pressures up to 400 p.s.i. Wide choice of porting and mounting arrangements in both packed and mechanically sealed pumps. Write for General Catalog.

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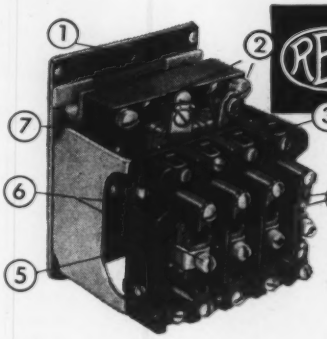

RBM INDUSTRIAL CONTACTORS

2 TO 8 POLE
600 VOLT A. C.
10—15 AMPERE SIZES
REVERSING—NON-REVERSING TYPES
INTERCHANGEABLE CONTACTS

1. Heavy steel base.
2. Coil readily replaced by removing 2 heavy screws holding E-shaped magnet frame.
3. Accessible solderless type terminals are conveniently located. All line terminals at top; load terminals at bottom.
4. Any pole can be changed from normally open to normally closed, or vice-versa, without additional parts.
5. Melamine stationary contact block and movable contact carrier.
6. Stationary and movable contacts can be readily replaced with use of screw driver only and without removing wiring.
7. Vacuum impregnated magnet coil designed for continuous 50/60 cycle service.

For descriptive bulletin No. 600-write Dept. H-1

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LOGANSPORT, INDIANA

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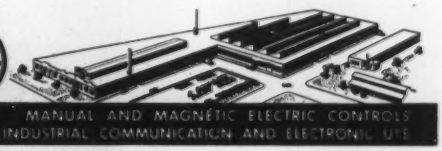

MANUAL AND MAGNETIC ELECTRIC CONTROLS
FOR AUTOMOTIVE, INDUSTRIAL COMMUNICATION AND ELECTRONIC USE

VENDING MACHINES EARN MORE ...both in production and "on location"

. . . when machine-builders "buy the idea" of AMERICAN PHILLIPS SCREWS

PRODUCTION "PAYOFFS" climb up toward jackpot levels, where American Phillips Screws are policing costs in all assembly departments. Workers work faster and better. Shiny surfaces are never gouged. For American Phillips Screws and drivers are fumble-proof, skid-proof, slash-proof. And they can be handled *by anyone* with such ease and speed that time-savings average *50% over slotted screws.*

STEADY "PLAYS" are sure to be attracted by smartly styled machines, assembled with modern, attractive American Phillips Screws . . . the screws with the universal crossed recess. No burred heads to snag clothes. No loosening of screws under vibration and incessant use. And no matter what *you* make or vend, chances are you can profit *doubly,* too, through the production savings and merchandising power of American Phillips Screws. Write.

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4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS

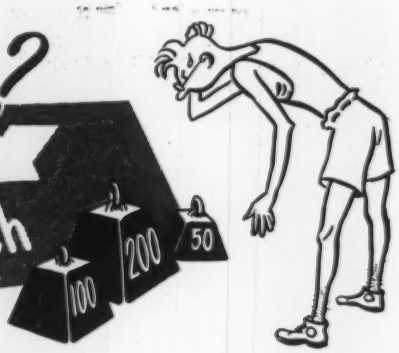
AMERICAN PHILLIPS *Screws*

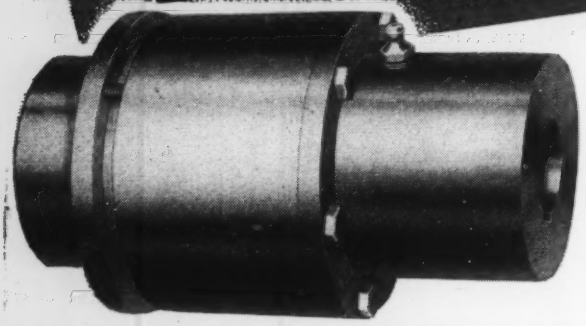
ALL TYPES

ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

WORRIED ABOUT CAPACITY?

SPECIFY A KINNEY Multi-disc Overrunning Clutch





The line of Kinney Clutches is complete — INTERCHANGE, OVERRUNNING, DRY PLATE, OIL TYPE AND WORRALL — for every service.

WITH the radically different Kinney Multi-disc Overrunning Clutch, capacity can be accurately determined—there's no guesswork in specifying the unit to exactly meet your load requirements. This new design eliminates the uncertain capacity of "cramp" type clutches which employ cams, rollers, or balls to handle both shifting and driving functions. In the Multi-disc, a separate, simple mechanism automatically shifts the clutch from full engagement to full release with positive and fatigue-proof reliability. The actual working load is carried by multiple friction discs of known capacity. This "two department" design gives two-fold safety—the Kinney Multi-disc gives instant pickup and carries the load with work-horse dependability. Capacities to 30 HP per 100 RPM—over 30 HP on special order.

Write today for information.

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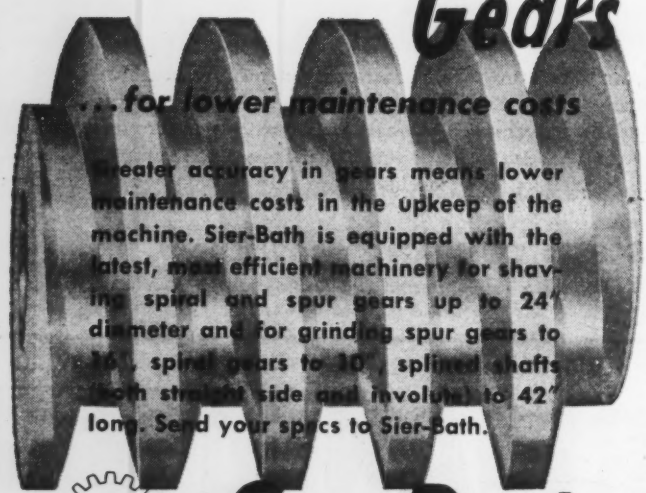
WE ALSO MANUFACTURE VACUUM PUMPS, LIQUID PUMPS AND BITUMINOUS DISTRIBUTORS

Sier-Bath

GROUND or SHAVED Gears

. . . for lower maintenance costs



Greater accuracy in gears means lower maintenance costs in the upkeep of the machine. Sier-Bath is equipped with the latest, most efficient machinery for shaving spiral and spur gears up to 24" diameter and for grinding spur gears to 16", spiral gears to 10", splined shafts (both straight side and involute) to 42" long. Send your specs to Sier-Bath.

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9263 HUDSON BOULEVARD NORTH BERGEN, N. J.

VERSATILE

SB-1 CONTROL AND TRANSFER SWITCH

Over 10,000 circuit-sequence combinations are possible with this versatile control and transfer switch. Rated up to 20 amperes at 600 volts a-c or d-c. Compact, sturdy construction. Mount on panels ⅛ to 2 inches thick. Easy to order, too . . . see your G-E sales representative about the SB-1. Write for bulletin GEA-4746. *Apparatus Department, General Electric Company, Schenectady 5, New York.*

GENERAL ELECTRIC

NEW DISPOSABLE BABY BOTTLE

Pre-sterilized . . . soft and pliable, yet strong . . . made of Du Pont polythene

Here's the answer to a mother's prayer . . . an end to baby-bottle drudgery. It's a disposable nursing bottle everyone can afford, made of Du Pont polythene plastic.

Invented by a registered nurse, these bottles collapse as the infant feeds, eliminate back pressure within the bottle. So there's less air for the baby to swallow. Soft, pliable and warm in use, these bottles have been called "the nearest approach to natural feeding." Many pediatricians have approved them.

These "Shellie Disposa-Bottles" are made from polythene extruded as continuous flat, sterile tubing, which is then heat-sealed at intervals to form sections with 4-oz. or 8-oz. capacity. Bottles are cut from the tubing with scissors in the home, then fitted with plastic tops, placed in a rack, filled with formula and nippled. After warming, they're used, then thrown away. These bottles are tough and strong, won't tear or leak. They're made of Du Pont polythene because its unusual combination of properties fits the requirements to a T.

A good idea—plus a Du Pont plastic—is a winning combination for new or improved products. Write today for literature on polythene and other versatile Du Pont plastics. E. I. du Pont de Nemours & Co. (Inc.), Plastics Department, Room 391, Arlington, N. J.

Shellie Disposa-Bottles, nipples, bottle fittings, rack and bottle expander included in "Shellie Nurser Layette Set," made by Shellmar Products Corp., Mt. Vernon, Ohio.

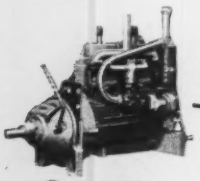
Tune in—Du Pont's famous "Cavalcade of America"—Monday night, NBC coast to coast!

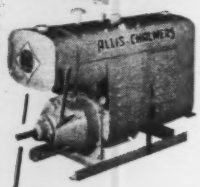
DU PONT
Plastics
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

WIDE CHOICE OF POWER

...Stationary or Mobile

Many different models and sizes of Allis-Chalmers engines and tractors to choose from, with accessories to fit the application.



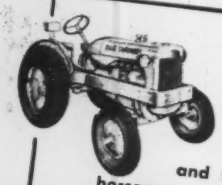


★ POWER UNITS

Designed for tough tractor service, high in torque, A-C heavy-duty power units provide rugged power for every type of job, steady or intermittent. Available in open or enclosed styles, with various accessories. Choice of fuels — gasoline, low-grade fuel, natural gas or butane.

FIVE SIZES

Model	Cylinders	R.P.M.	Max. Brake HP.
B-125	4	1500-1800	24.5 - 28
W-201	4	1400-1800	33.5 - 40.5
U-318	4	1200	45
E-563	4	1050	74
L-844	6	1050	110

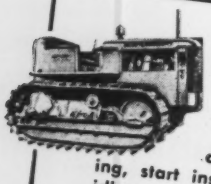


★ WHEEL TRACTORS

Popular, economical Allis-Chalmers wheel tractors provide mobile power you can depend upon, at the drawbar or power take-off. Available in 4-wheel and tricycle designs. Various speeds and horsepower ratings. Mounted on rubber tires. Electric starting and lights, other accessories as desired. Gasoline, kerosene, or distillate.

FIVE MODELS

Model	Drawbar HP.	Max. Speed MPH	Max. Belt HP.	R.P.M.
IB	13.5	10.0	16.3	1400
B	13.5	10.0	16.3	1400
C	13.5	7.06	23.3	1500
WF	23.7	9.77	29.93	1300
WC	23.7	9.77	29.93	1300



★ CRAWLER TRACTORS

Powerful, smooth-operating, these A-C 2-cycle Diesel crawler tractors hang onto overloads with the tenacity of steam power. Operate on ordinary Diesel fuels, require less gear shifting, start instantly. Positive seal truck wheels and idlers require lubrication only once in 1000 hours.

FOUR MODELS

Model	Drawbar HP.	Max. Speed MPH	Max. Belt H.P.	R.P.M. at Max. Torque
HD-5	40.26	5.47	50.25	800-1200
HD-7	60.10	5.00	71.08	800-1200
HD-10	86.63	6.03	101.62	800-1200
HD-19	*	7.00	*	800-1200

*Hydraulic Torque Converter Drive—163 HP. at the flywheel.

ALLIS-CHALMERS
TRACTOR DIVISION • MILWAUKEE 1, U. S. A.

Diagram shows double-acting air cylinder operated by Valvair 4-way solenoid valve, spring return.

DEPENDABILITY — That's outstanding in Valvair performance. Solenoids are Stellite-welded to resist wear; do not mushroom. Standard Valvairs have operated over 2,000,000 times at 100 lbs. with never a leak. *Exclusive features.* Patented basic design eliminates metal seats; non-corrosive (cast bronze body, stainless steel parts); full pipe area used with minimum drop. 2-way, 3-way, 4-way types. Get full details and prices.

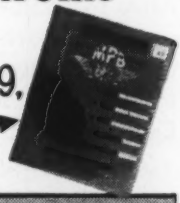
Ask for Bulletin "AD"

VALVAIR CORPORATION • 454 Morgan Avenue, Akron 11, Ohio

Valvair

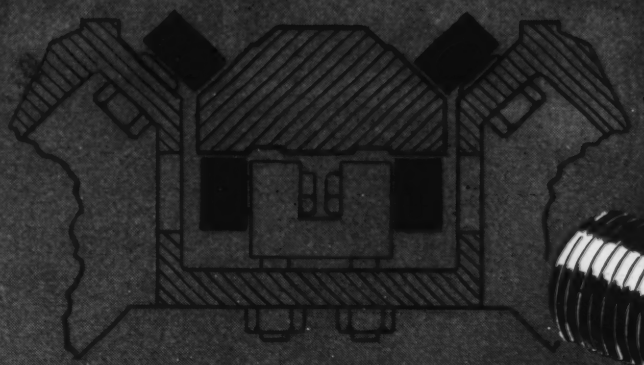
The new No. 418 Miniature Ball Bearing: ¼" o.d. ○ ⅛" bore. Available in both chrome steel and stainless.

Write for Catalog 49, gives complete data →

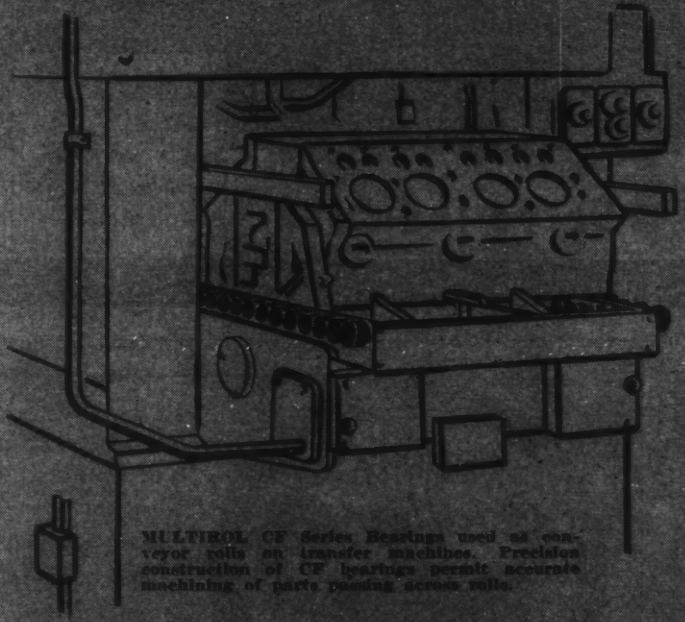


MPB MINIATURE Precision BEARINGS
INCORPORATED
KEENE, NEW HAMPSHIRE, U.S.A.

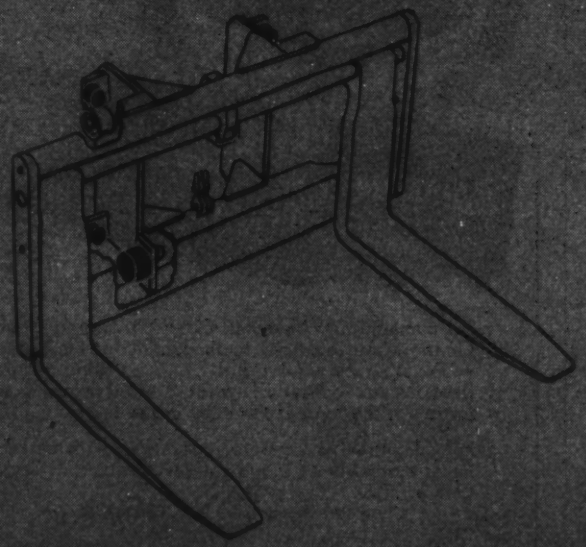
Increase Machine Efficiency



MULTIROL CF Series Bearings as support rollers for oscillating heads and tables on machine tools. Saves costly grinding and scraping of ways.



MULTIROL CF Series Bearings used as conveyor rolls on transfer machines. Precision construction of CF bearings permit accurate machining of parts passing across rolls.

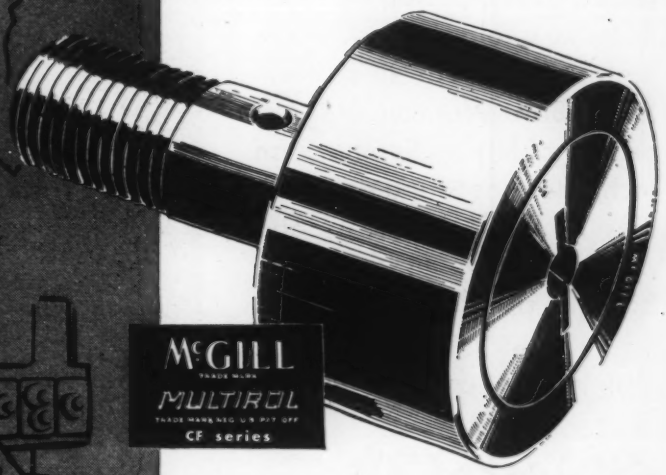


MULTIROL CF Series Bearings as mast and platform guide rollers on lift trucks. Ensure lifting and side adjustment of heavier loaded platforms.

with . . .

ANTI-FRICTION PERFORMANCE

the MULTIROL way

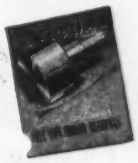


When your design goal is the ulumate in anti-friction performance . . . when your specifications include heavier static and shock load capacity . . . then MULTIROL Cam Follower (CF series) bearings are what you've been looking for.

The Cam Follower is a rugged bearing. An extra heavy outer race section stands the repeated shock of cam operation. A full complement of small diameter rollers make up an almost unbroken steel ring which distributes the load evenly over a greater bearing surface. Internal wear and friction are held to the minimum, and power requirements of MULTIROL bearing equipped machines are appreciably lessened. CF bearings are easily lubricated through the stud or face of the bearing and sufficient lubrication is retained for adequate protection of those neglected applications.

MULTIROL Cam Follower bearings are precision built in a range of twenty-two standard roller diameters from ⅜" to 4". This wide variety eliminates the need for special cam follower specifications in most machine design.

For dependable and long lasting anti-friction applications, at lower cost, investigate MULTIROL CF series bearings. Ask our engineers for their recommendations.



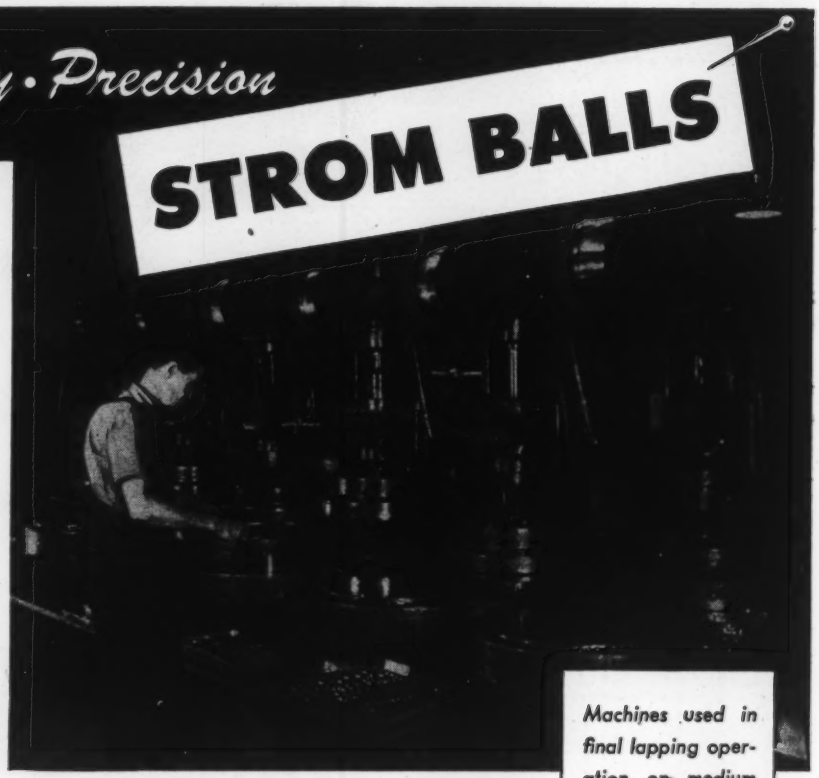
Write for Bulletin CF-40A. McGILL Manufacturing Company, Inc., 200 North Lafayette Street, Valparaiso, Indiana.

Surface • Sphericity • Precision

STROM BALLS

It takes a long series of processes, developed and perfected over a period of years, to make a thing as faultless in material and form as a Strom Metal Ball. Worked to a tolerance of fifty millionths of an inch, their outstanding qualities of finish, sphericity and precision have made Strom Balls the standard of industry.

Strom Steel Ball Co., 1850 So. 54th Ave., Cicero 50, Illinois.



Machines used in final lapping operation on medium and large Strom Balls.

Strom BALLS Serve Industry

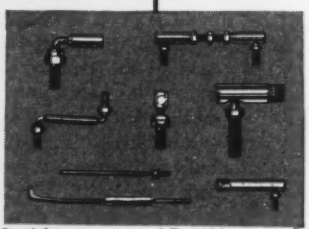
LARGEST INDEPENDENT AND EXCLUSIVE METAL BALL MANUFACTURER

TOUREK BALL JOINTS and SCREW MACHINE PRODUCTS

1 BALL JOINTS

The use of Tourek Ball Joints has helped many manufacturers to improve product performance, simplify design and reduce costs. These benefits are yours too when you specify Tourek!

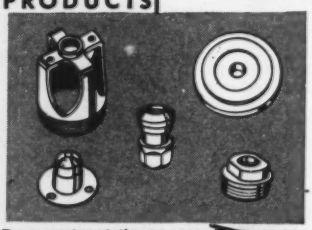
Whether your specifications call for standard or special Ball Joints, you can depend upon Tourek performance, delivery and prices!



Send for your copy of Tourek's 16-page Ball Joint Catalog. It fully describes 12 standard types in 54 sizes (carried in stock), and has data on special types as well.

2 SCREW MACHINE PRODUCTS

Tourek's modern plant—from the tool room to the batteries of giant 6-spindle automatics—is geared to turn out your screw machine product needs in any size up to 2⅝", from any type of metal. Twenty-eight years of production experience back up every job which Tourek undertakes.



For prompt quotation on your screw machine products requirements, simply send blueprint or sample.

MAKERS OF QUALITY SCREW MACHINE PRODUCTS

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4701 W. 16th St., Chicago 50, Ill.

ESTABLISHED 1920
TOUREK
FAMOUS BALL JOINTS

CINCINNATI *Coniflex**

Smoother . . . Quieter OPERATION
. . . WIDER OPERATING TOLERANCE

An outstanding characteristic of Cincinnati Coniflex* Gears is the localized tooth contact. This permits a wider operating tolerance . . . allowing slight deflections in operation without dangerous concentration of the load at the ends of the teeth.

For smoother . . . quieter operation, with easier and faster assemblies . . . we suggest Cincinnati Coniflex* Gears.

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COMMON SENSE ASSEMBLY ENGINEERING

Puts Fastening Costs in a Better Light

MAKES PARKER-KALON TYPE Z SERVE DUAL PURPOSE . . . SAVES 35%

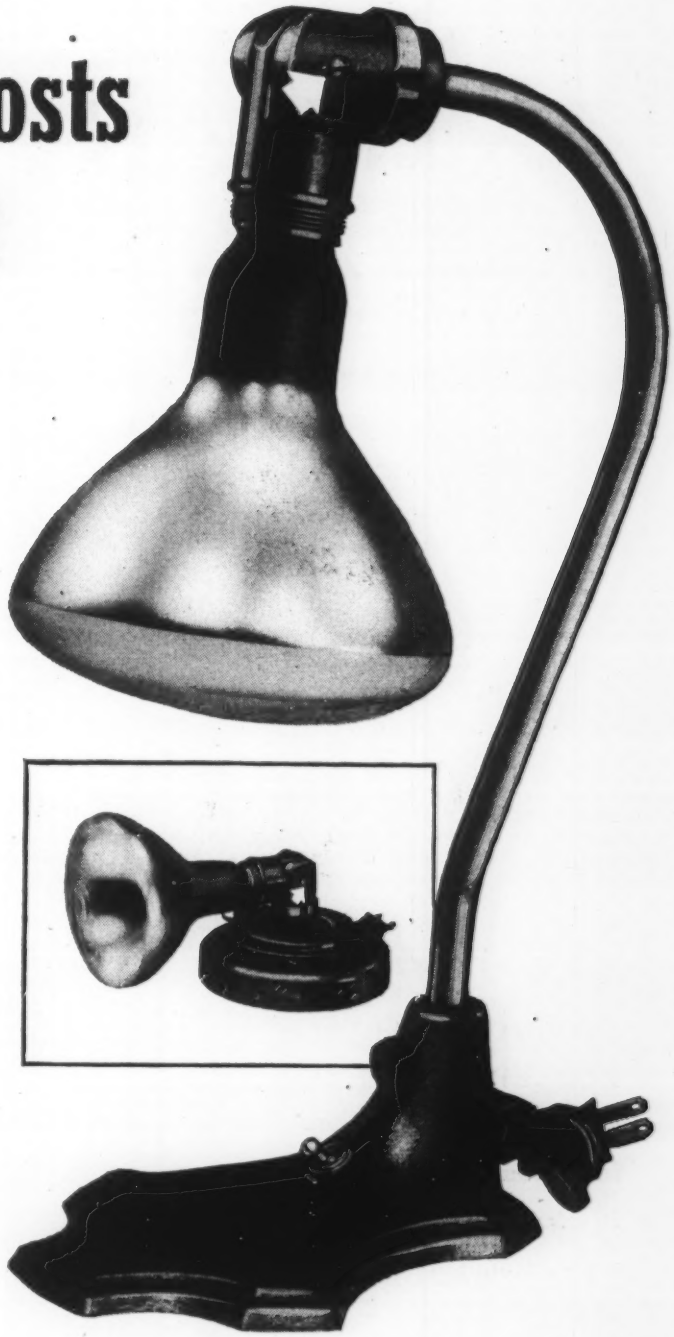
To make the price of these adjustable fixtures as practical as the lamp itself, the manufacturer—**Penetray Corp., Toledo, Ohio**—had to "go light" on fastening costs. That meant fast assembly with as few operations as possible.

But the fasteners had to serve a dual purpose . . . attach the plastic Hemisphere socket to the fixture's metal base (or gooseneck) and function as pivots to permit a 180° sweep of the socket.

P-K Self-tapping Screws were selected because they not only eliminated troublesome tapping and tap breakage, but also provided the hardened tips of the screws to serve as long-wearing pivots. Thus, they permitted a simpler, smoother design, and helped brighten the cost picture with a 35% assembly saving!

Why not examine your own fastening methods in the light of common sense assembly engineering. Very likely you, too, can benefit by switching to the simpler Parker-Kalon method. Call in a P-K Assembly Engineer. He can show you that in 7 out of 10 cases, use of P-K Self-tapping Screws saves up to 50% in assembly work hours. If you prefer, mail assembly details for recommendations. Parker-Kalon Corp., 200 Varick St., New York 14, N. Y.

Sold Only Through Accredited Distributors



Two P-K Countersunk Oval Head Type "Z" Self-tapping Screws fasten plastic socket to metal base of fixture and also serve as pivots for Hemisphere socket which moves 180° in a vertical plane. P-K Screws need only to be driven in plain holes . . . form their own threads . . . assure a strong fastening.

P-K® *the Original*

A TYPE AND SIZE FOR EVERY METAL AND PLASTIC ASSEMBLY

PARKER-KALON SELF-TAPPING SCREWS

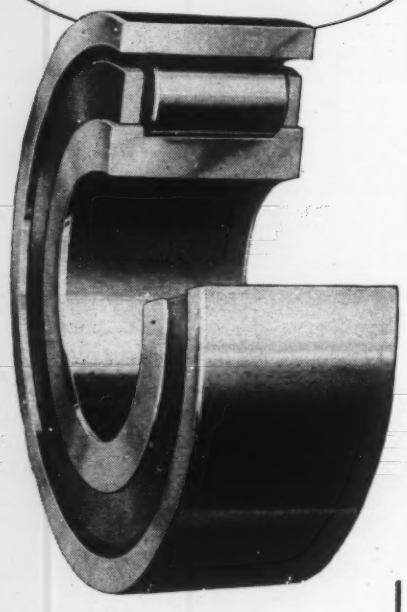
PARKER-KALON PRODUCTS COLD-FORGED SOCKET SCREWS, WING NUTS, THUMB SCREWS • HARDENED SCREWNAILS AND MASONRY NAILS SHUR-GRIP FILE AND SOLDER IRON HANDLES • METAL PUNCHES • DAMPER REGULATORS AND ACCESSORIES

Install Them and Forget Them!

AMERICAN

RADIAL

Roller Bearings



AMERICAN RADIAL ROLLER BEARINGS are engineered to exacting standards that result in better performance and minimum maintenance.

Furnished in 5 styles, 6 S.A.E. series and 85 sizes. Special designs also available. Write.

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420 Melwood Street Pittsburgh, Pa.

Pacific Coast Office: 1718 S. Flower St., Los Angeles, Calif.

For HIGHEST ELECTRICAL & MECHANICAL *Efficiency!*

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Improved Socket Contacts. Four individual flexing surfaces. Positive contact over practically their entire length.

Both Plug and Socket Contacts mounted in recessed pockets greatly increasing leakage distance, INCREASING VOLTAGE RATING. Plug and Socket Contacts cadmium plated. Add to appearance of your equipment. Interchangeable with Jones 400 Series.

Ask for Catalog 17, Complete line Jones Plugs, Sockets, Terminal Strips.

P-2406-CCT
Plug — with cable clamp in top.

S-2406-SB
Socket with shallow bracket for flush mounting.

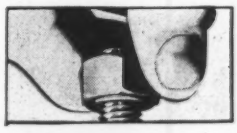
HOWARD B. JONES DIVISION

Cinch Mfg. Corp.

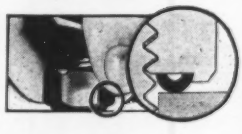
2460 W. GEORGE ST. CHICAGO 18, ILL.

Fast, Safe, Adaptable

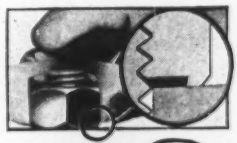
... the An-cor-lox lock nut



1. Spins on fast by hand. One piece. All metal. Available in high, standard, thin and acorn or cap designs.



2. Tightens just like an ordinary nut. Ideal for primary setup. Locking ring at base of nut; no extra stud length required.



3. Ring grips bolt with vibration and shock-proof grip. No axial play. Standard wrenches. Re-usable many times.

4. When backed off, locking ring *stays* locked! Prevents "walking off" even if other parts of assembly loosen.

Don't select your lock nut until you've tested An-cor-lox. Send today for descriptive literature and free standard samples.

An-cor-lox TRADE MARK REGISTERED *Lock Nuts*

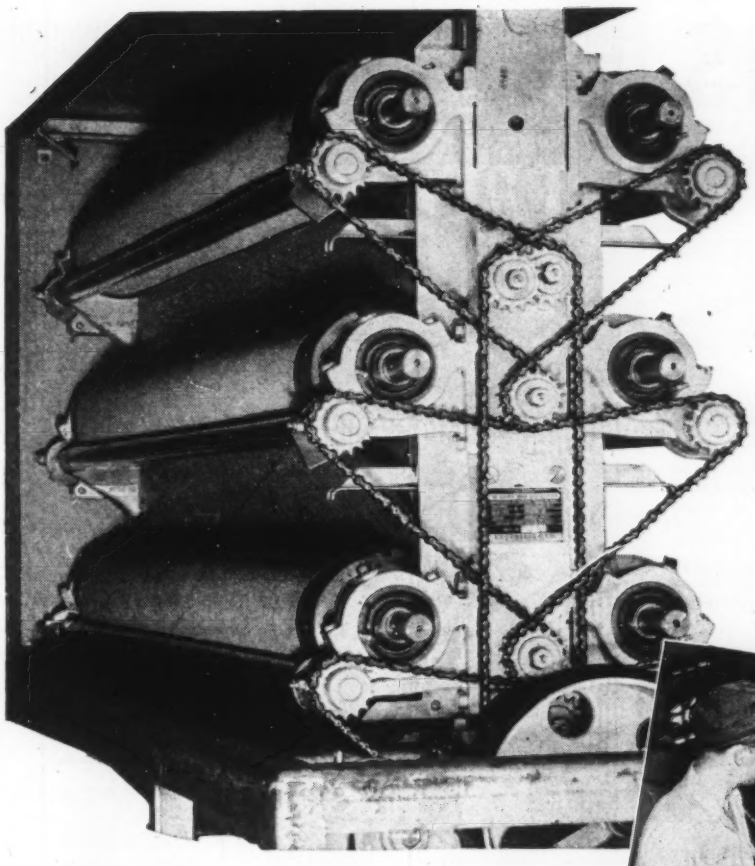
LAMINATED SHIM CO., Inc., *An-cor-lox Division*, 1201 Union St., Glenbrook, Conn.

AN COR LOX NUTS • SHIMS • SHIM STOCK • STAMPINGS

Wichita City Librar

DIAMOND DRIVES

MEET DESIGN DEMANDS



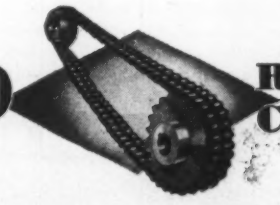
This is a good example of multiple shaft chain drive application by the makers of the well-known Clipper Super Seed Selector made by the A. T. Ferrell & Co. of Saginaw, Michigan.

The builder who engineered this steel plate forming machine selected Diamond Roller Chain Drives to transfer power from motor to reducer, then to three shafts. Note, since both faces of Diamond Chain are the same, it can be run over or under the sprockets. Fabweld Corp., Nowata, Oklahoma.

● For simple drives from one shaft to another — for the driving of several shafts — for drives of fractional or several thousand horsepower—slow or high speeds—Diamond Roller Chains have aided machinery design engineers to secure greater dependability and efficiency of performance. Constant speed ratios are assured — load is distributed over many teeth — there is no separating force — bearing wear is reduced — placement of shafts is no problem since sprockets may be so close that teeth almost touch or may be far apart.

Dependably long-life performance and *uniform* high quality are reasons for Diamond's wide acceptance by leading machinery builders of America. DIAMOND CHAIN COMPANY, Inc., 435 Kentucky Avenue, Indianapolis 7, Indiana. *Offices and Distributors in All Principal Cities.*

Where great reserve strength, long-life dependability, high maintained efficiency are essential, Diamond Roller Chains are selected by leading builders of heavy machinery. Such a drive as on the big Lima Dragline Excavator is shown here.

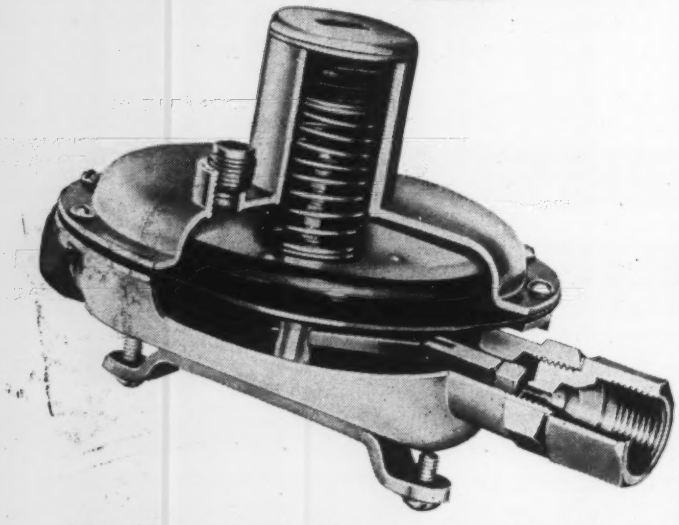
DIAMOND  **ROLLER CHAINS**

DIAPHRAGMS

by

LINEAR

Engineered for Your Needs



LINEAR, a recognized leader in the field of precision moulded diaphragms, is constantly alert to the ever-changing needs of industry.

The super-sensitive diaphragm shown here is another example of LINEAR Diaphragms built to *your* specifications—*custom made but mass produced* . . . LINEAR Diaphragms that are precision moulded permit easier assembly, lower costs and make positive fluid or gas-tight seals.

LINEAR'S reputation has been built on the ability of our engineers to specify materials and design patterns that will produce the most efficient diaphragm for the specific application.

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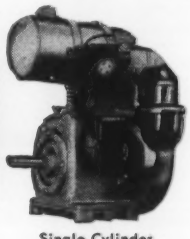
WISCONSIN *Air-Cooled* ENGINES

You Get . . .



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- Weather-proof, automatic cooling . . .
- Foolproof lubrication . . .
- Quick, sure-fire starting in any climate, at any season . . .
- Full load power delivery on a continuous service basis if that's what the job calls for . . .
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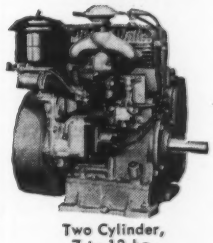
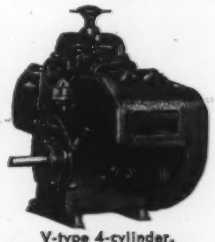
- Popular and enthusiastic recognition and endorsement in all fields of engine power service . . .
- Your choice of power to fit the machine and the job in 4-cycle single cylinder, 2-cylinder and 4-cylinder engines, in a power range from 2 to 30 hp.

Let us supply you with full details, including engineering data applying to your specific power problems.



Two Cylinder, 7 to 13 hp.



V-type 4-cylinder, 15 to 30 hp.

MOST H.P. HOURS

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

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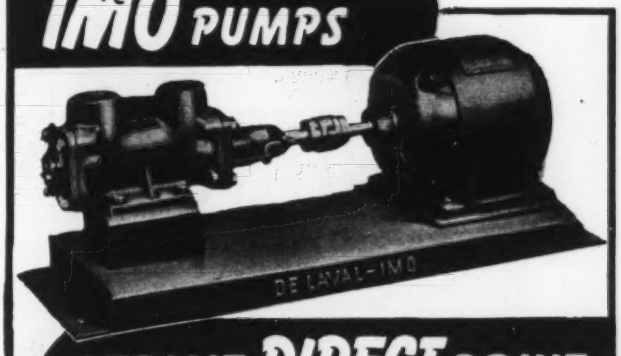
IMO PUMPS



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The IMO pump can be connected directly to turbines, motors or other machinery without the use of reduction gears.

Operated at high speed, it is exceptionally small and compact in proportion to its capacity.

IMO pumps can be furnished for almost any capacity and pressure required for pumping oil, hydraulic control fluids and other liquids over a wide viscosity range.

For further information send for catalog I-138-D

IMO PUMP DIVISION of the DE LAVAL STEAM TURBINE CO.
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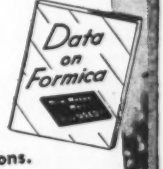
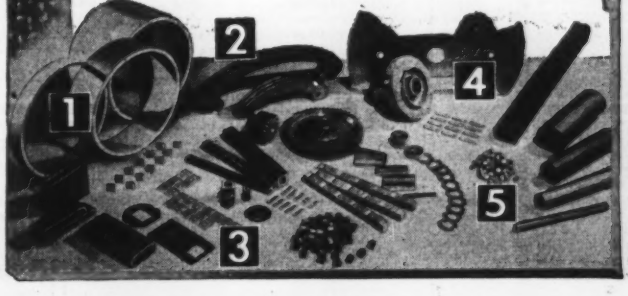
Formica Parts are at work in every type of Industry. Just to stimulate your own creative thinking on how Formica fits your production picture, some of the parts illustrated are identified here:

1. Tubing for Electrical Insulation.
2. Cable Guides used on Elevators.
3. Contact Post Insulators for Automotive Generator Cutouts.
4. Condenser Spacer, Aviation Industry.
5. Washing Machine Silencer Spring Buttons.

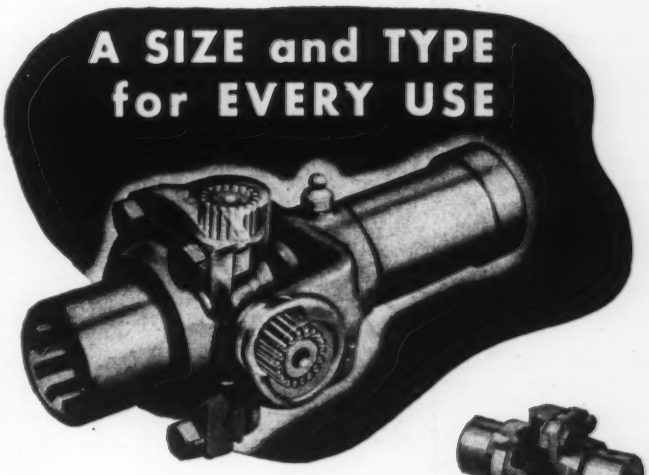


Let us know how you are considering Formica. It can be custom built to meet your requirements. "Data on Formica" and typical samples are available. Help us help you. Write FORMICA, 4545 Spring Grove Ave., Cincinnati 32, Ohio.

Productive FORMICA at Work in Industry



A SIZE and TYPE for EVERY USE



MECHANICS makes the most complete line of SIZES and TYPES of Roller Bearing UNIVERSAL JOINTS — for every application. Sizes range from 200 to 50,000 foot pounds torque, with a wide variety of end connections and shaft arrangements. Millions of cars, trucks, busses, tractors, farm, construction and industrial machines, and aircraft of all types benefit from design and manufacturing advantages of MECHANICS (Lifetime or Once-a-Season Lubricated) Roller Bearing UNIVERSAL JOINTS. In addition to conventional applications, we make joints for steering columns, etc. Our new catalog — showing the complete line of MECHANICS Roller Bearing UNIVERSAL JOINTS will be sent to manufacturers, upon request.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner BW
2032 Harrison Avenue
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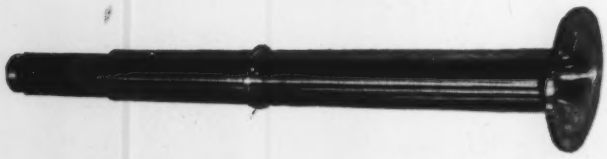
For Cars · Trucks · Busses and Industrial Equipment

We have quite a following too~

A following that is growing steadily. Our customers, over the past 43 years, have continued to send us their toughest gear problems. They have known that IGW's skilled craftsmen can meet their most rigid specifications.



The Main Drive Shaft for the Sikorsky S-52 Helicopter

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Standard Locknuts, Lockwashers and Adapters are *vibration-proof* devices for holding ball or roller bearings in place. Hard wear and tear cannot shake them loose, they are easily removed, and can be used again and again. Locknuts can be locked in a permanent and correct position by multi-prong Lockwashers.

Locknuts in sizes N-00 through AN-40 . . . Lockwashers (multi-prong type) in sizes W-00 through W-40. Write for Bulletin 27.

Adapter sizes 7-9-11-13, for shaft sizes 1 3/16" - 1 7/16" - 1 15/16" - 2 3/16".

Standard

LOCKNUT & LOCKWASHER, INC.

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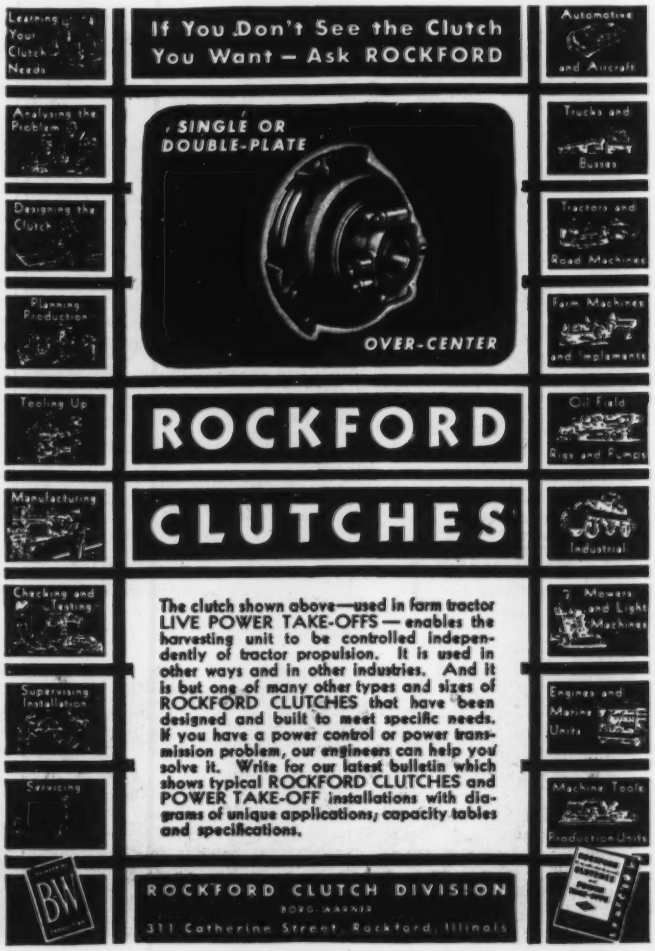
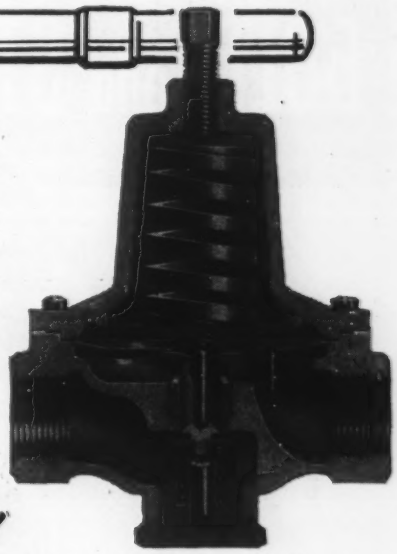

If You Don't See the Clutch You Want – Ask ROCKFORD
SINGLE OR DOUBLE-PLATE
OVER-CENTER
ROCKFORD
CLUTCHES
The clutch shown above—used in farm tractor LIVE POWER TAKE-OFFS — enables the harvesting unit to be controlled independently of tractor propulsion. It is used in other ways and in other industries. And it is but one of many other types and sizes of ROCKFORD CLUTCHES that have been designed and built to meet specific needs. If you have a power control or power transmission problem, our engineers can help you solve it. Write for our latest bulletin which shows typical ROCKFORD CLUTCHES and POWER TAKE-OFF installations with diagrams of unique applications, capacity tables and specifications.
ROCKFORD CLUTCH DIVISION
311 Catherine Street, Rockford, Illinois

the key to
CORRECT AIR PRESSURE

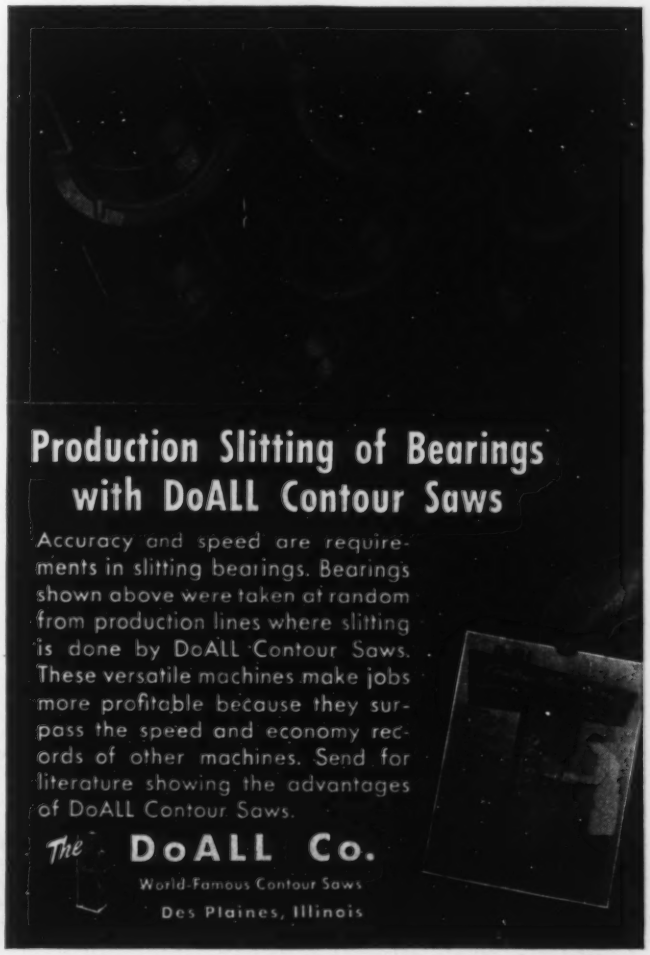


NORGREN REGULATORS deliver smooth, even air flow at the CORRECT pressure—improving your machine performance—reducing wear. Floating diaphragm assures decisive valve action and long life. Baffle plate cushions diaphragm against shock—prevents valve chatter. Syphon action permits larger volume of air to pass with *less pressure drop* than conventional regulators. Types for air, oil, water, steam and non-corrosive gases. Write to C. A. Norgren Co., 222 Santa Fe Drive, Denver 9, Colorado.

"Wherever Air Is Used In Industry"

Norgren

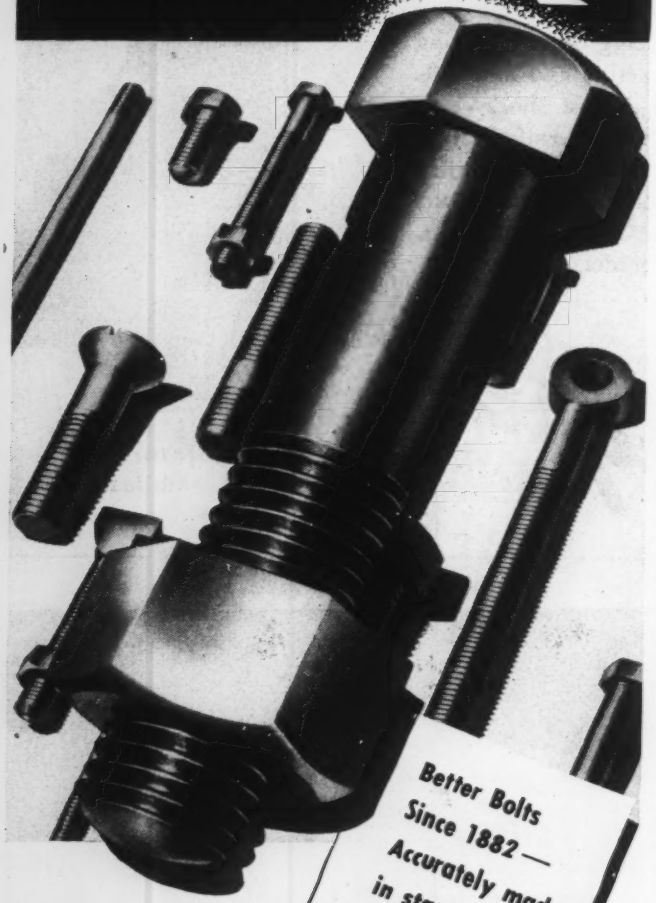
Lubricators, Regulators, Filters, Hose Assemblies


Production Slitting of Bearings with DoALL Contour Saws
Accuracy and speed are requirements in slitting bearings. Bearings shown above were taken at random from production lines where slitting is done by DoALL Contour Saws. These versatile machines make jobs more profitable because they surpass the speed and economy records of other machines. Send for literature showing the advantages of DoALL Contour Saws.
The DoALL Co.
World-Famous Contour Saws
Des Plaines, Illinois

HERE THEY ARE

Stainless Steel

BOLTS and STUDS



Better Bolts Since 1882— Accurately made in standard dimensions or to meet your specifications.

Carbon Steel— Heat-treated Alloy Steels — Stainless Steel — Silicon Bronze — Brass — Bronze — Monel Metal.

USE HEADED AND THREADED FASTENERS FOR ECONOMY AND RELIABILITY

PAWTUCKET

"The Bolt Man"

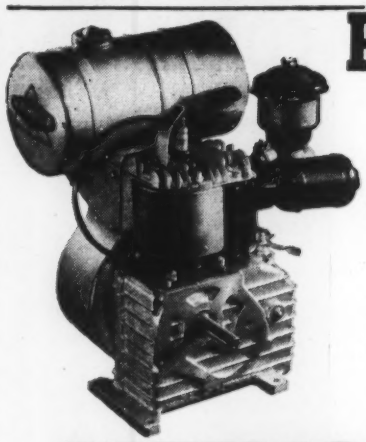
MANUFACTURING COMPANY

327 Pine Street · Pawtucket, R. I.

THE PLACE TO SOLVE YOUR BOLT PROBLEMS

Need more HORSE POWER?

(2.4 H. P.)



● with LESS WEIGHT?
(approx. 43 lbs.)

● in LESS SPACE?
(approx. 13½" x 12½" x 18")

ULTIMOTOR

2.4 H.P.—4 CYCLE—AIR COOLED

● Here's the engine that hums your tune! Smaller, lighter than most engines with even lower rating . . . it's precision machined for quality and trouble-free operation due to new engineering features. Centrifugal type governor, geared pump with forced feed and splash oil system, high tension crankshaft magneto. Better performance per dollar!

For Full Information Write Box MD
Write For NEW Direct Factory—Dealer Plan

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Put your gear requirements in the hands of long experienced *gear specialists,* with every modern facility. Spur, bevel, worm, helical, internal gears, any quantity, small or large, cut exactly to your specifications from any gear material. Prompt delivery. Write, wire, phone.

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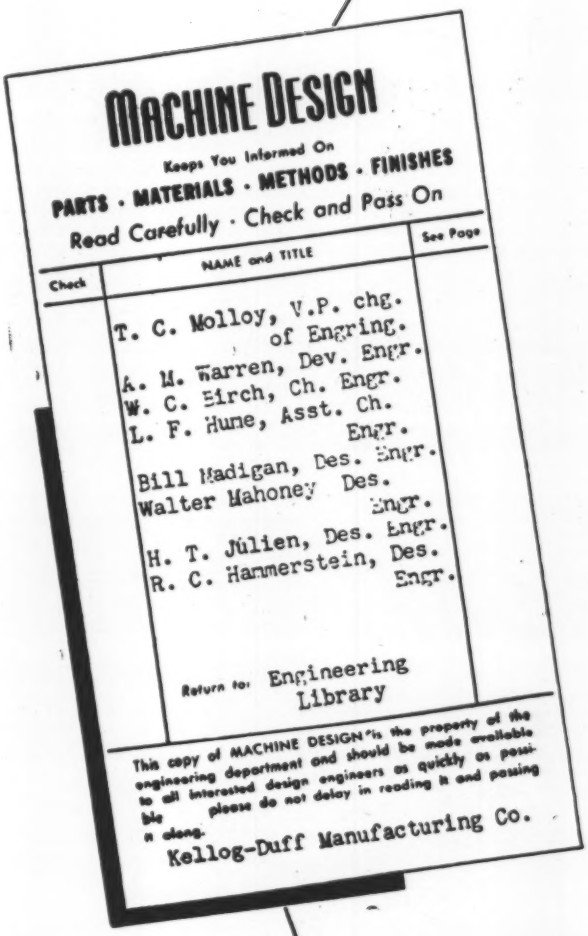
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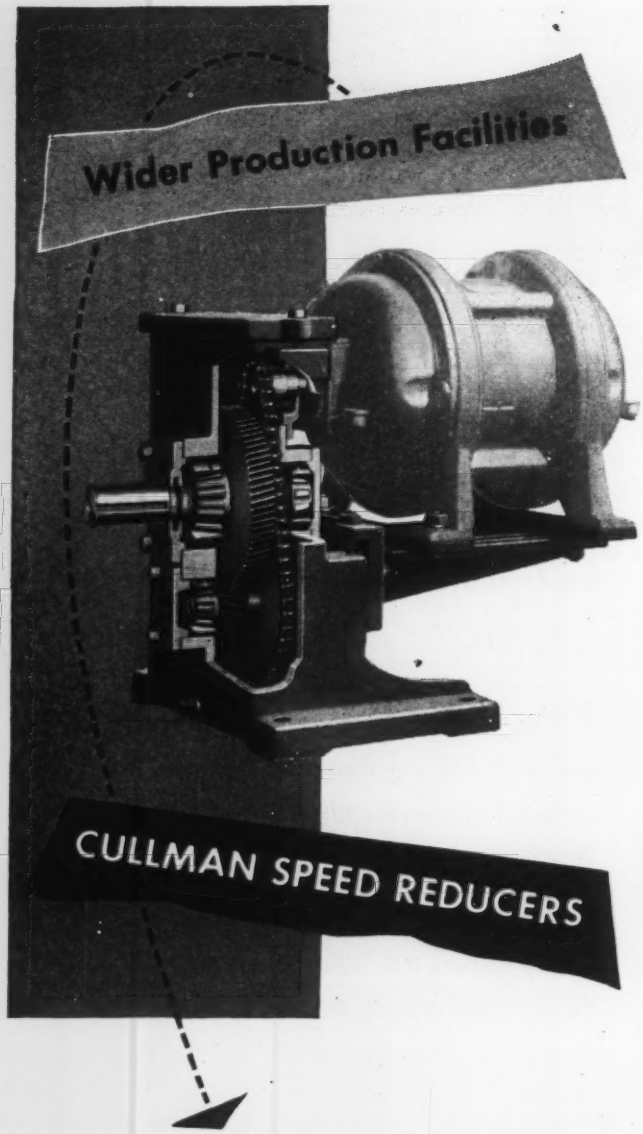


The wide range of Cullman speed reducers—¼ to 15 H.P.—provides the ideal size and type for most requirements. They enable you to achieve far wider production facilities for existing motor equipment.

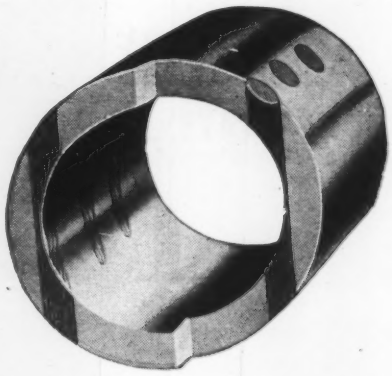
Cullman drives, single and double reduction, are equipped with roller or ball bearings and sturdy helical gears, all moving mechanism operating in oil. Flange type motors are directly connected to the reduction case.

Write Today—ask for your copy of the useful Cullman Speed 24 page Reducer Book. It is replete with blue prints, photographs and numerous tables of ratings, and prices to promote quick selection and delivery.

CULLMAN WHEEL COMPANY

1336 ALTGELD STREET • CHICAGO 14, ILLINOIS

Just Try **1** MOCCASIN BUSHING...



ON YOUR MOST TROUBLESOME BEARING

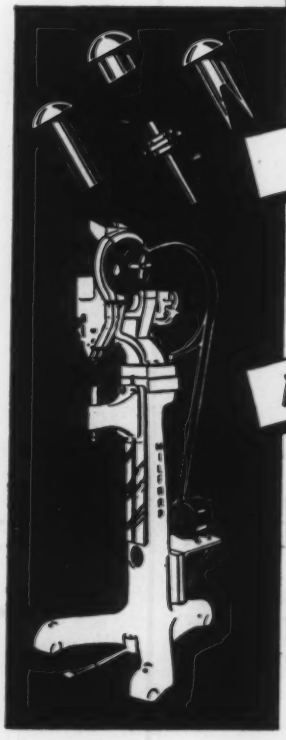
and be convinced

The success of Moccasin Bushings' efficiency lies in their unique lubrication principle. Oil is drawn from a reservoir in the bearing housing and is distributed by capillary action in a continuous, unbroken film over the entire bearing surface. Drippage and seepage of oil is entirely eliminated, and under ordinary circumstances they require attention only two to four times a year—just try one on your most troublesome bearing. Guaranteed for satisfactory service. Write for folder No. 428 showing nine other styles of bushings.

MOCCASIN BUSHING COMPANY
Chattanooga • Tennessee

SAVE

- MATERIALS
- MAN-HOURS
- MONEY



with the . .

RIGHT RIVETS

Select exactly the right semi-tubular, split rivet, or cold-headed fastener from Milford's complete line. You'll find it pays in every way!

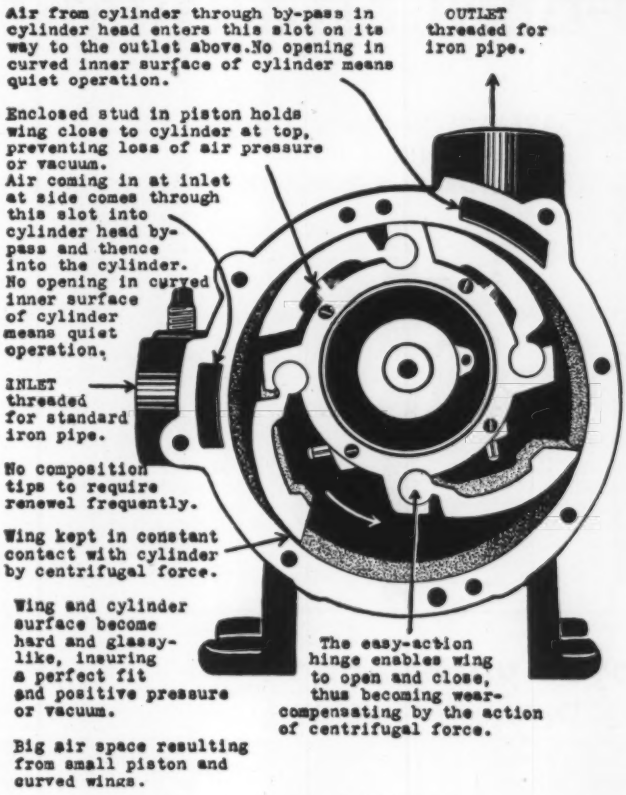
RIGHT MACHINE

Then use the right rivet setting machine for your application. One of Milford's 15 basic machines is sure to solve your particular problem . . . and slash your production costs!

WRITE TO DEPT. G

MILFORD RIVET & MACHINE COMPANY
HATBORO, PENN.
ELYRIA, OHIO
MILFORD, CONN.

IMPORTANT BUSINESS REQUIRES CORRECT DECISIONS!


Air from cylinder through by-pass in cylinder head enters this slot on its way to the outlet above. No opening in curved inner surface of cylinder means quiet operation.
OUTLET threaded for iron pipe.
Enclosed stud in piston holds wing close to cylinder at top, preventing loss of air pressure or vacuum.
Air coming in at inlet at side comes through this slot into cylinder head by-pass and thence into the cylinder. No opening in curved inner surface of cylinder means quiet operation.
INLET threaded for standard iron pipe.
No composition tips to require renewel frequently.
Wing kept in constant contact with cylinder by centrifugal force.
Wing and cylinder surface become hard and glassy-like, insuring a perfect fit and positive pressure or vacuum.
Big air space resulting from small piston and curved wings.
The easy-action hinge enables wing to open and close, thus becoming wear-compensating by the action of centrifugal force.

THAT'S WHY WE SAY THAT CORRECT OPERATION OF YOUR PROCESS, MACHINE OR DEVICE CALLS FOR CORRECT VACUUM IMPULSE THROUGH THE PUMP THAT TAKES UP ITS OWN WEAR

LEIMAN BROS. ROTARY VACUUM PUMPS

AIR MOTORS-GAS BOOSTERS

On Automatic Machines of Many Styles and Functions Including Paper Feeding, Dehydrating, Pump Priming, Gas Boosting, Liquid Agitation, etc.

OPERATORS OF Feeding Machines and Devices Handling Sheets of Paper or Other Materials Prefer These Vacuum Pumps Because of Their Trouble-Proof Operation!

LEIMAN BROS., INC.

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HALLOWELL

Steel Collars

"Hallowell" Solid Steel Collars, functionally proportioned throughout, are precision-machined so faces run perfectly true . . . are also highly polished all over . . . yet they cost less than common cast iron collars. 3" bore and smaller are made from Solid Bar Stock. To make sure the collar won't shift on the shaft, they are fitted with the famous "Unbrako" Knurled Point Self-Locking Socket Set Screw—the set screw that won't shake loose when once tightened. "Hallowell" . . . a "buy word" in shaft collars . . . available in a full range of sizes for

IMMEDIATE DELIVERY

"Hallowell" Products are sold through Industrial Distributors.

OVER 46 YEARS IN BUSINESS

STANDARD PRESSED STEEL CO.

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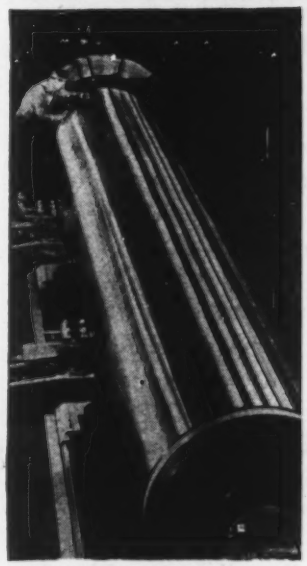


FINISH MACHINING AND POLISHING WORLD'S LARGEST CENTRIFUGAL BRONZE CASTING.

LARGEST YET!

World's largest centrifugal bronze casting—54" O. D. by 328" length.

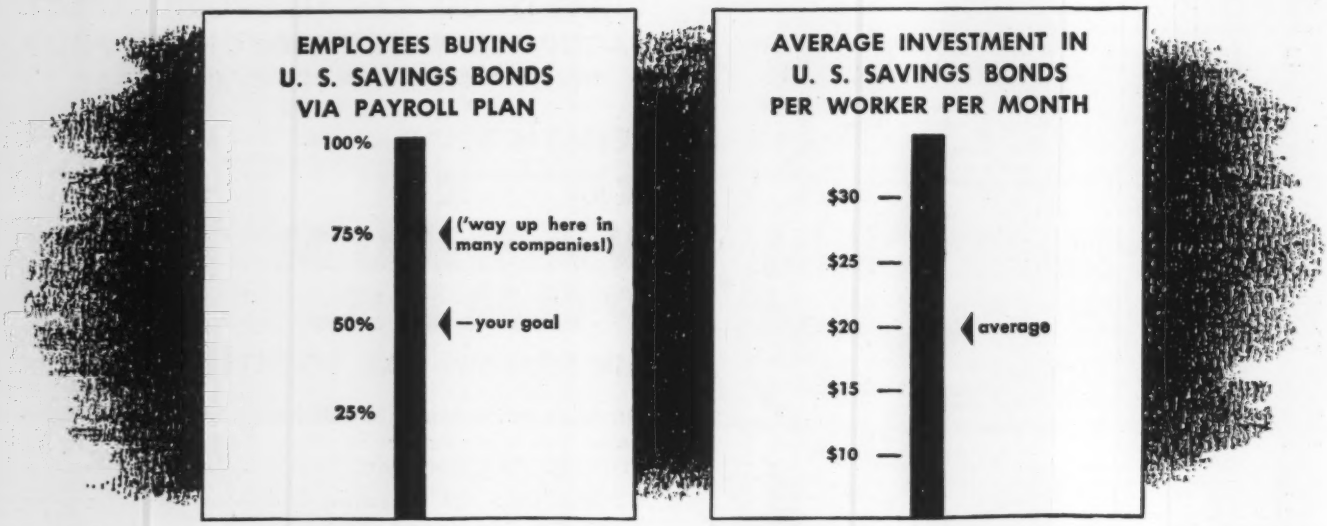
A close examination of its 14' circumference—at any point along its 27' length—will find it flawless.

Fine grain structure, uniformity, and freedom from porosity characterize *all* our castings. That's why it will pay you, when ordering centrifugal castings, to specify Chief Sandusky.

CHIEF SANDUSKY *CENTRIFUGAL CASTINGS*

SANDUSKY FOUNDRY AND MACHINE CO. SANDUSKY OHIO, U.S.A.

How is YOUR company doing in this "EVERYBODY-BENEFITS" plan?



Compare your employee participation with others who have Payroll Savings

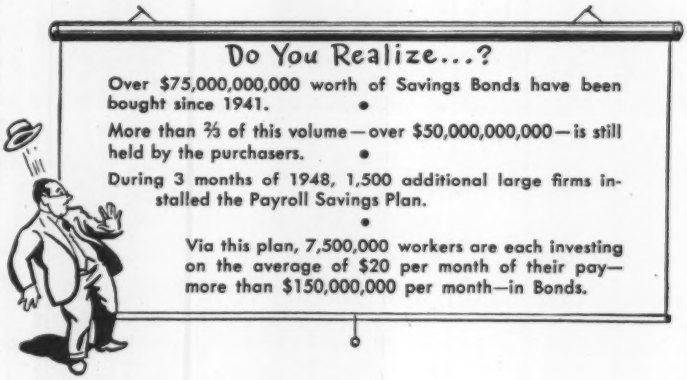
If the figures for your company fall below those shown above, you're missing your share of benefits of the Payroll Savings Plan! These benefits are described below. Nation-wide experience proves that when top management puts the "OK" on the Plan, its benefits rise sharply.

BENEFITS TO *EMPLOYEES:* Every $3 invested in Savings Bonds pay $4 at maturity. Workers gain a 33⅓% return on their money—enabling them in the future to buy more of the things they will want—plus the peace of mind that goes with regular saving.

BENEFITS TO *EMPLOYERS:* The feeling of security that goes with participation in Payroll Savings makes workers more contented. Worrying less, they work better. Among the more than 20,000 large companies with Payroll Savings, records show that—following installation of the Plan—production increased, absenteeism and accidents decreased!

BENEFITS TO THE *NATION:* The Payroll Savings Plan is a powerful deterrent to inflationary forces. Every Savings Bond dollar built up in the Treasury withdraws a dollar from the swollen spending stream. The Plan thus contributes to national security—which affects *your* security!

WHAT CAN *YOU* DO? If your company has the Payroll Savings Plan, make sure it's being adequately promoted—backed by your top executives—to bring your company its full measure of benefits. If you haven't yet installed the Plan, why pass up its benefits any longer? All the help you need is available from your State Director, Savings Bonds Division, U. S. Treasury Department. He is listed in your telephone book. Call him now!


Do You Realize...?
Over $75,000,000,000 worth of Savings Bonds have been bought since 1941.
More than ⅔ of this volume—over $50,000,000,000—is still held by the purchasers.
During 3 months of 1948, 1,500 additional large firms installed the Payroll Savings Plan.
Via this plan, 7,500,000 workers are each investing on the average of $20 per month of their pay—more than $150,000,000 per month—in Bonds.

The Treasury Department acknowledges with appreciation the publication of this message by

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PRESSURE PROBLEM?

USE OUR 25 YEARS

OF "KNOW HOW" IN THE manufacture of AUTOMATIC VALVES

Special valves developed to fit your equipment.

Standard models of our Pressure Reducing Valves, Pressure Relief Valves, Strainers, etc., for water, air, steam, oil, gas and liquid service, are available for immediate delivery.

Write for your free copy of our 1948 Catalog giving full details about CASH-ACME Products and services.

CASH-ACME Automatic Valves

A.W. CASH VALVE MANUFACTURING CORPORATION

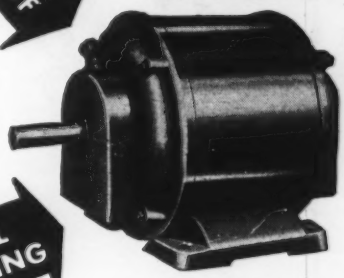
6813 EAST WABASH AVENUE DECATUR, ILLINOIS, U. S. A.

Here's Your MOTOR

DRIP PROOF

SPLASH PROOF

BALL BEARING



- IT'S COOL RUNNING
- IT'S ECONOMICAL TO OPERATE

Selecting a power unit for especially designed machinery or for standard equipment is not a difficult task when you consider that VALLEY MOTORS are built to meet *any* design demand.

Furthermore, you have the added assurance of dependability because of the nationwide acceptance by machinery manufacturers in all industries who have used VALLEY MOTORS for many years.

Why Not Check Into VALLEY Features

VALLEY ELECTRIC CORPORATION

4221 FOREST PARK BLVD. • ST. LOUIS 8, MO.

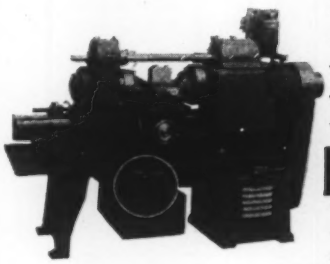


Photo Courtesy The R. K. LeBlond Machine Tool Co. showing a LeBlond #1 Crankshaft Lathe with 1/10 HP Model 1-P3 Gusher Coolant Pump.

FOR A BETTER COOLANT PUMP . . . SPECIFY

RUTHMAN GUSHER COOLANT PUMPS

Comparison will show you that Improved Ruthman Gusher Coolant Pumps have many points of superiority.

You are assured of better Coolant performance when you use Ruthman Gusher Coolant Pumps on your machines.

Write for new catalog today.

THE RUTHMAN MACHINERY CO.

1811 Reading Road Cincinnati 2, Ohio

DROP FORGINGS

Let us quote on your requirements

Producers of Quality Forgings for over 25 years

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ANCHOR, CHAIN & FORGE DIVISION of The Boston Metals Company

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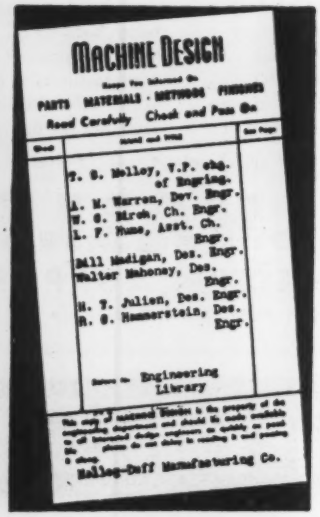
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★Chief Engineer ★Hydraulic Engineer
★Plant Superintendent ★Maintenance Superintendent

NO HYDRAULIC CIRCUIT IS COMPLETE WITHOUT A MARVEL SYNCLINAL FILTER AT THE INTAKE OR SUCTION SIDE OF THE PUMP.

• Marvel Synclinal Filters are your safeguard against costly breakdowns occurring from pipe scales, dirty oil, and other harmful matter which clogs the fine tolerance valve openings. Why gamble with equipment worth thousands when you may MARVELIZE your hydraulic equipment at a cost that will prove insignificant compared to the price of a jammed or wrecked hydraulic circuit costing thousands.

2½ TIMES MORE FILTERING AREA THAN EQUIVALENT SIZE CIRCULAR TYPE FILTERS.

This means maximum filtration in less space. Standard 100 mesh (.0050 opening) insert—others range from coarse 30 mesh to fine 200 mesh inserts. Adaptable to meet any filtering problem.

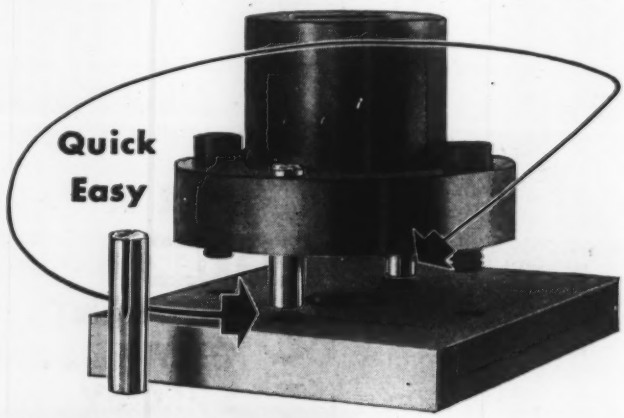
SUMP TYPE IN 6 CAPACITY SIZES—5 PIPE SIZES

—5, 8, 10, 30, or 50 gal. per minute. In increased capacity easily obtainable with manifold installations.

Write for Catalog #103 containing complete engineering data.

MARVEL ENGINEERING COMPANY

625 W. Jackson Blvd. Dept. 51, Chicago 6, Ill.



LOCATING

Design and Production men alike find that Driv-Lok Pins, used as locating or positioning pins, save time and labor in the assembly of machine components, jigs and fixtures. Installation is simple—merely drill a hole and drive in the pin.

Products of every description have been improved and costs reduced by the use of DRIV-LOK Pins. Perhaps they can serve you in *your* production problems. Our Catalog suggests many typical applications of these versatile pins. Write for it —there is no obligation.

DRIV-LOK PIN COMPANY
715 Chauncey Street, Sycamore, Illinois

SEE WATSON-FLAGG

FOR GEARS —

QUALITY GEARS

WHERE END PERFORMANCE

DEPENDS ON GEARMAKERS' SKILL

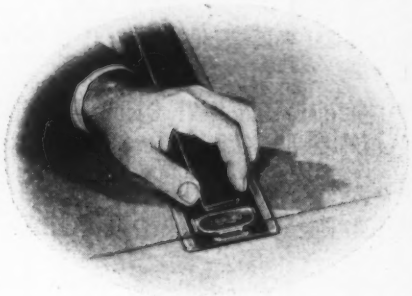
MEMBER OF AGMA

WATSON-FLAGG MACHINE COMPANY, Inc.

Paterson, New Jersey

YOU'LL LIKE

The E-Z GRIP Straightedge!

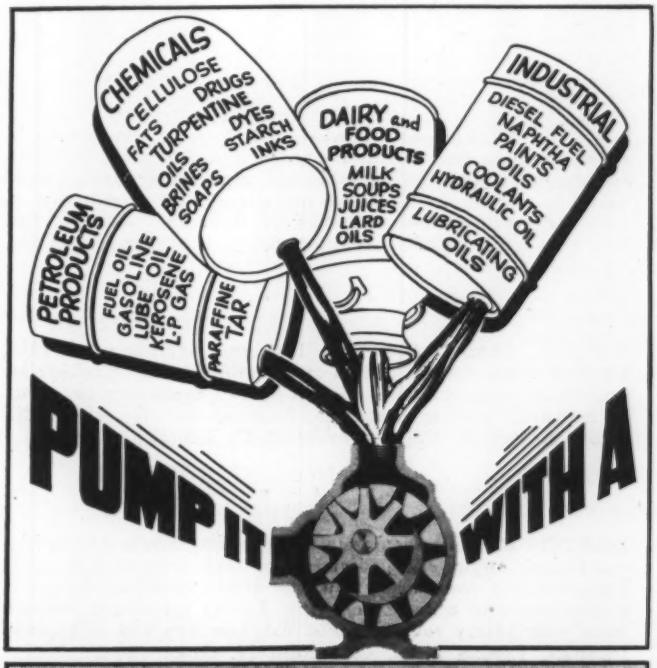


BECAUSE:

- The full length beveled finger grip affords finger tip control of the straightedge.
- Made from high grade laminated plastic, the straightedge is unaffected by heat or moisture.
- Transparent edges set above lower surface of blade avoids blotting and smearing of ink. Edges stay clear.
- Available in sizes from 30 to 72 inches. 60 inch E-Z Grip priced at only $20.00

ENGINEERING MANUFACTURING COMPANY

627 NO. COMMERCE ST. SHEBOYGAN, WISCONSIN



VIKING

If your problem is to pump any of these or similar liquids, look to Viking for your answer. Capacities ½ to 1050 gpm—pressures to 200 psi,—500 psi on hydraulic oils. Send for free bulletin 47SH today.

See Our Catalog In SWEETS

Viking PUMP COMPANY

Cedar Falls, Iowa

Solenoid

STAINLESS STEEL

Valves

ACTUAL SIZE

★ Standard pressure range, 5 to 250 psi
★ Dimensions 2¾" high x 1⅝" dia.
★ Impregnated coils withstand moisture and condensation
★ Soft insert seats prevent leakage
★ Spring loaded for positive action
★ Stainless steel parts highly resistant to corrosion and wear
★ Power consumption 10 watts max.
★ Pipe connections to specification
★ Also many special valves for handling pressures from 5 to 850 psi

THREE WAY - TWO POSITION
TWO WAY - NORMALLY CLOSED
TWO WAY - NORMALLY OPEN

Skinner will be pleased to make recommendations on your particular design applications — they have for hundreds of others. Write today for details and catalog.

SKINNER ELECTRIC VALVES

Skinner ELECTRIC VALVE DIV.

THE SKINNER CHUCK COMPANY

133 Belden Ave., Norwalk, Conn.

WANTED
FOR DIVERSIFICATION

- MECHANICAL PROCESSING MACHINERY OF PRECISION TYPE
- MECHANICAL EQUIPMENT EMBODYING PRECISION GEARING OR CAMS
- SPECIAL-PURPOSE MACHINE TOOLS
- MAJOR COMPONENTS OF MECHANICAL EQUIPMENT

Our client, a well established manufacturer of medium size automatic machinery, will buy a business based on such products or will buy manufacturing rights for products fully engineered and market proven—sales volume in one or more lines up to two million dollars annually.

Interested in retaining competent executive, engineering and sales personnel.

Would consider contract manufacture looking toward ultimate merger.

Please write Department "B-5" enclosing this ad. Your reply will be held in confidence if desired.

We are fully compensated by our client.

CHARLES H. WELLING & CO., INC.
52 Vanderbilt Avenue, New York 17, N. Y.
Consultants in New Product Development

BROWNING
STEEL CABLE GRIPBELTS

MORE *Strength* • LESS *Stretch*

Browning Steel Cable Gripbelts are much stronger than ordinary belts. They will safely carry heavier loads with fewer belts. They will stretch less and give longer life without loss of power and efficiency.

Write FOR LIST PRICE SHEET V-163-A

BROWNING MANUFACTURING CO.
INCORPORATED
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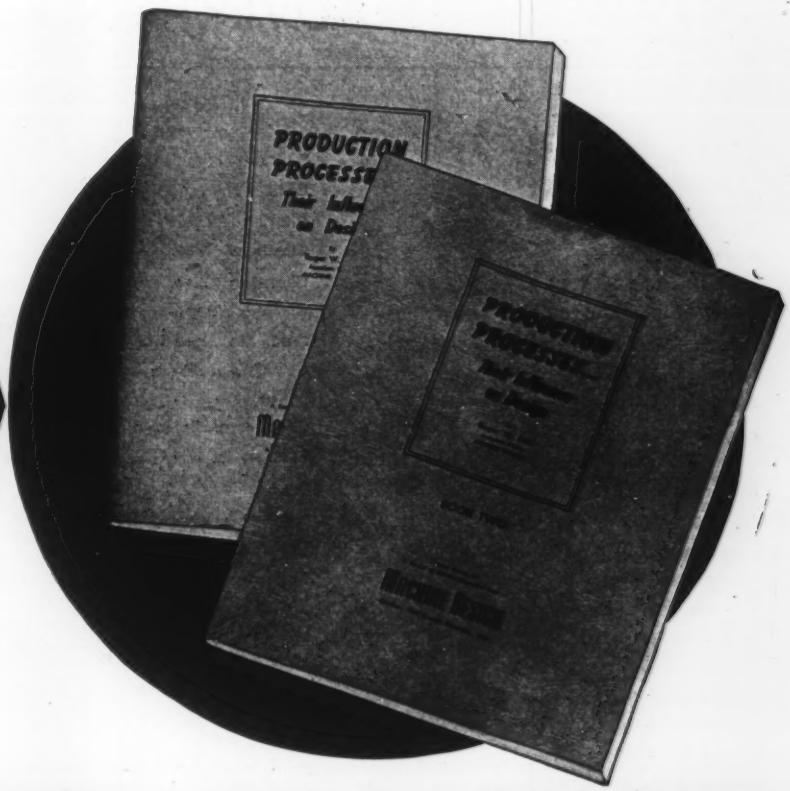

BY ROGER W. BOLZ
Associate Editor, Machine Design

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SECOND 15 CHAPTERS OF PRODUCTION PROCESSES

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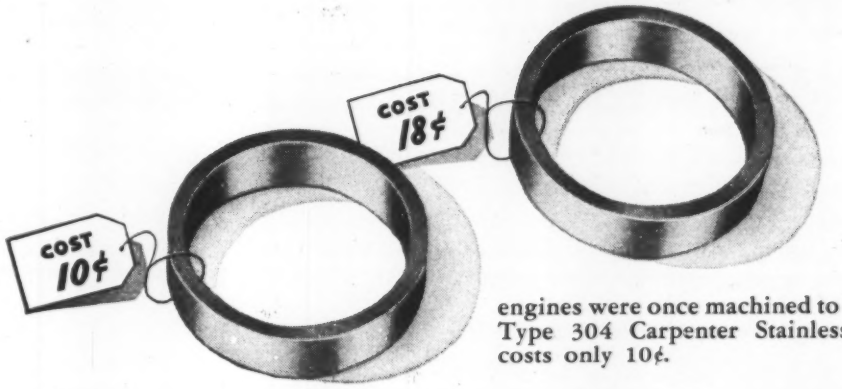

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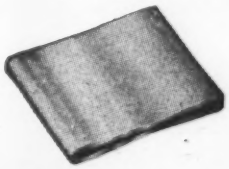
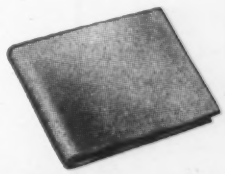


FLATTENING TEST protects you against the possibility of O.D. defects. Specimen is flattened between parallel plates until distance between plates is 3 times the tube's wall thickness. Any sign of cracking or flaws is cause for rejection.



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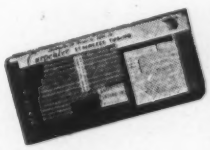

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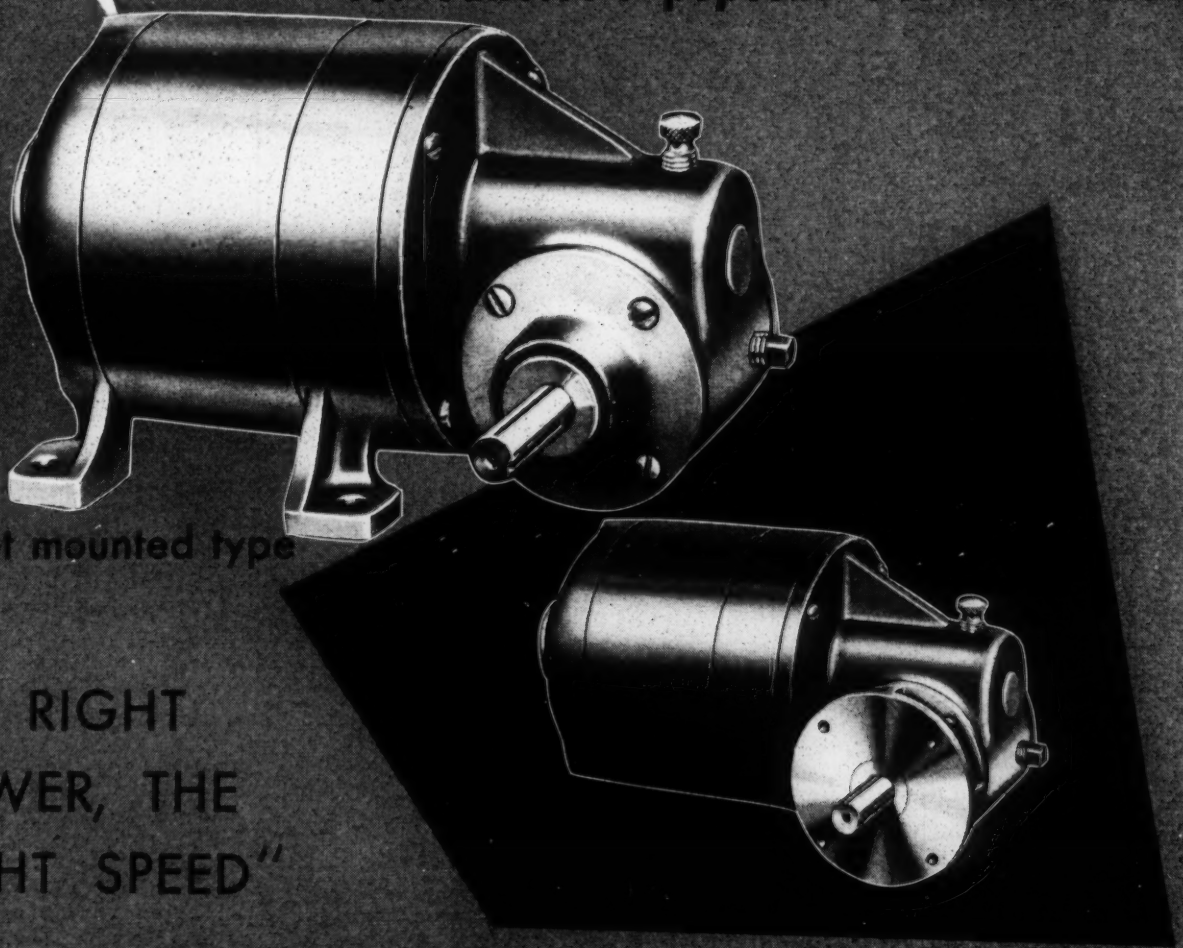

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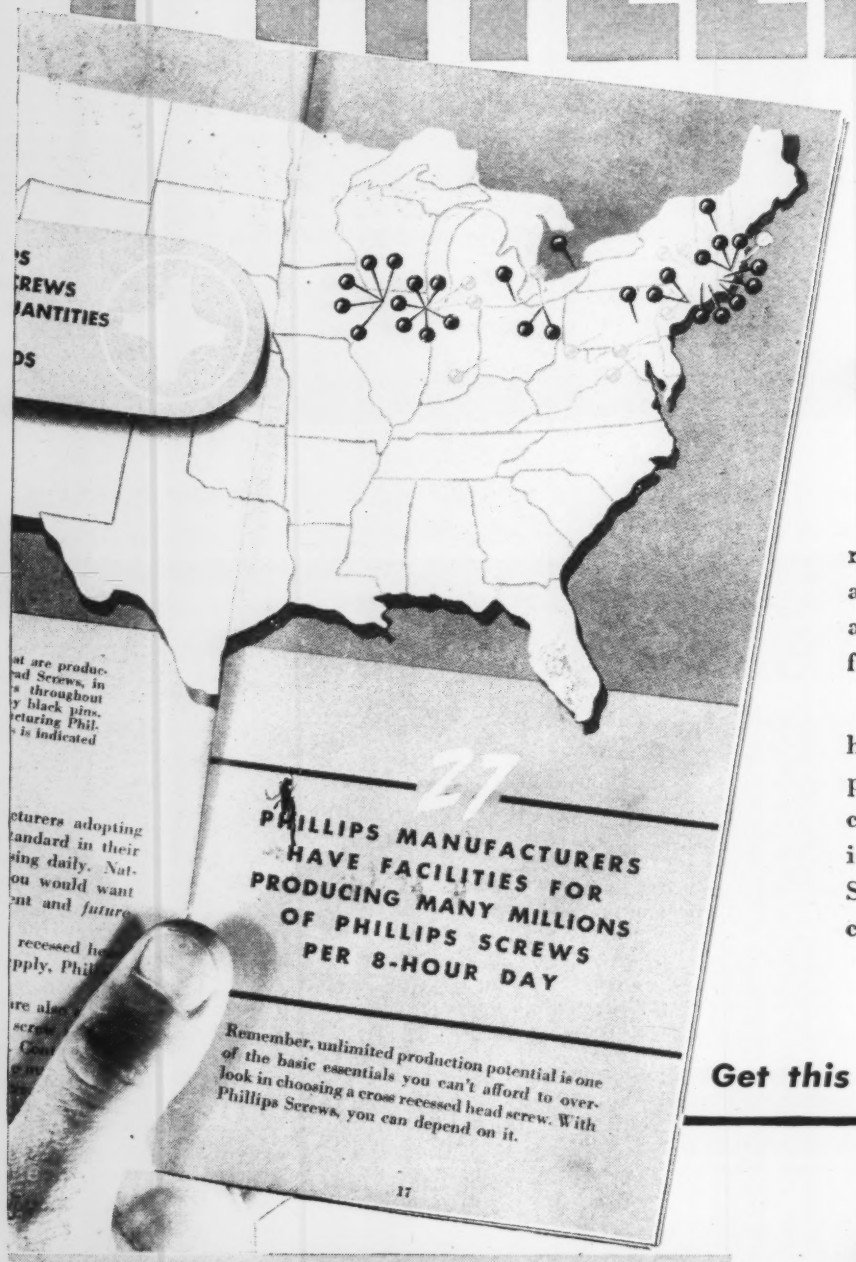
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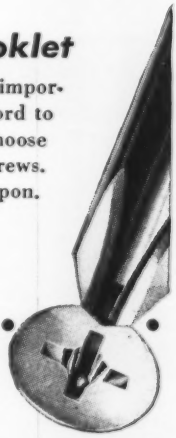

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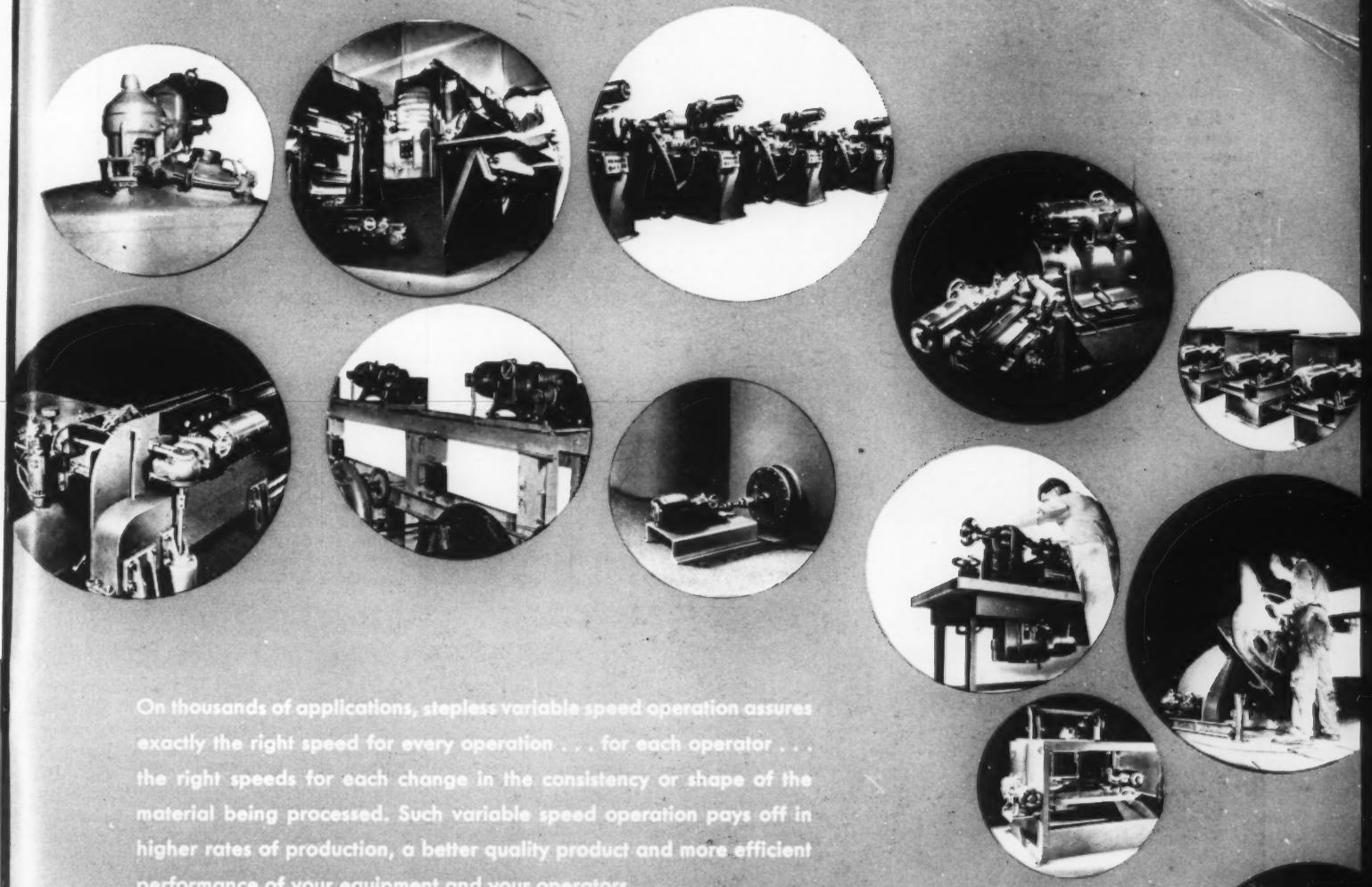

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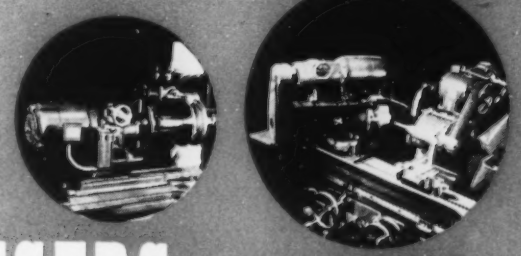

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